ACS

Basic

Graphics Programming

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On The Cutting Edge of Technological Evolution

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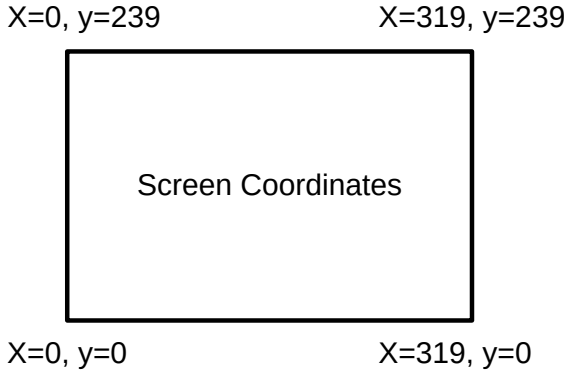
ACS Basic Graphics Programming

ACS Basic provides several commands to draw graphics. When used with the Color LCD 320x240 Terminal the graphics are displayed on an actual LCD display screen. When used with the CFSound-IV the graphics are displayed on a virtual screen that may be viewed and interacted with via a VNC network connection. In this manual the word 'display' refers to the Color LCD 320x240 Terminal LCD display screen or the CFSound-IV virtual display screen.

Screen Coordinates

The graphic drawing commands use pairs of numbers to identify where you want to draw on the display. In computer terminology these are referred to as ***screen coordinates***. The first number of the pair is the X coordinate and identifies a horizontal starting point that ranges from zero to one less than the width of the display (0 – 319). The second number of the pair is the Y coordinate and identifies a vertical starting point that ranges from zero to one less than the height of the display (0 – 239). The X and Y coordinates for drawing start at **0, 0** at the lower left corner of the display and range to 319, 239 at the upper right corner of the display as shown in this diagram:



Drawing is clipped at the coordinate boundaries of the display – commands that specify coordinates outside of these boundaries will not affect the display when either coordinate exceeds these values.

Pixels

The screen is divided up into thousands of dots arranged in columns (0 – 319) and rows (0 – 239) that can be individually colored with one of 65536 colors. In computer terminology these dots are referred to as ***pixels***. The pixel color is selected by specifying the amount of three pure color components that are added to form the desired color – the amount of Red, the amount of Green and the amount of Blue. In computer terminology this is referred to as an ***additive RGB color model***.

The display supports 32 Red levels (0 – 31), 64 Green levels (0 – 63) and 32 Blue levels (0 – 31) for each pixel. There are more green levels than red or blue because the human eye is most sensitive to changes in green. Thirty two unique values can be determined using 5 binary bits, and sixty three unique values can be specified using 6 binary bits – so this form of RGB color encoding is known as RGB565. Hey – the total number of bits is 16 – the same number in our integer arithmetic! So, since the colors are additive, black must be equal to zero, and white must be equal to 65535 (largest 16-bit number).

The ACS Basic drawing commands allow your program to control the colors of one or more pixels at a time, depending upon the command, to draw graphic objects. The command to draw a single pixel is the simplest command – this table shows how the command is constructed and what the command arguments are (don't type this in directly, it is a description showing you how to construct this command):

DRAW.PIXEL x,y,color	
Sets the pixel at x,y on the current drawing @SURFACE to color	x screen x coordinate (0 – 319) y screen y coordinate (0 – 240) color RGB565 pixel color

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Let us use this description to construct a command that draws a white pixel at the center of the screen – don't worry about the @SURFACE system variable for now – we need to specify the x and y coordinates and the desired pixel color:

```
draw.pixel 160,120,65535
```

The white pixel is probably hard to see amongst the text on the screen – you could draw a red pixel that might be easier to see but how to you specify the red color? There is a built-in function for that.

The RGB(r, g, b) function takes three arguments, red level r (0 – 255), green level g (0 – 255) and blue level b (0 – 255) and does the math to combine them into a 16-bit integer – which is its return value. So let us use this to draw a red pixel:

```
draw.pixel 160,120,rgb(255,0,0)
```

Kind of hard to see – the individual pixels are kind of small and there is a lot of clutter on the screen. Let us use another system variable to stop showing the program text and PRINT output on the small screen – they will still show on your connected communications device. The ANSI operating mode can be turned off by setting the @ANSI.ENABLE system variable to zero:

```
@ANSI.ENABLE=0
```

Now as you type, or PRINT, the output doesn't affect the screen. As a default, so nobody wonders where their PRINT output, error message or Ready prompt went, the @ANSI.ENABLE is set to one whenever a program is run or stops running. So if you don't want ANSI output on the screen while your program is running you will have to turn it off at the beginning of your program, and keep your program running.

Clearing The Screen

One last thing – how do we clear the screen so we can see the pixel? Turns out that there is a command for that to – in computer terminology this is referred to a ***filling the screen***. Here is the command format:

DRAW.FILL x, y, width, height, color		
Sets the width by height pixels starting at x, y on the current drawing @SURFACE to color	x	screen x coordinate (0 – 319)
	y	screen y coordinate (0 – 240)
	width	number of pixels wide to fill
	height	number of pixels high to fill
	color	RGB565 fill pixels color

So try it:

```
draw.fill 0, 0, 320, 240, RGB(0, 0, 0)
```

You can experiment with different positions, widths, heights and colors. So now we have enough for a simple graphics program:

```
10 REM Draw a red pixel at the center of the screen
15 @ANSI.ENABLE=0
20 DRAW.FILL 0,0,320,240,RGB(0,0,0)
25 DRAW.PIXEL 160,120,RGB(255,0,0)
30 GOTO 30
```

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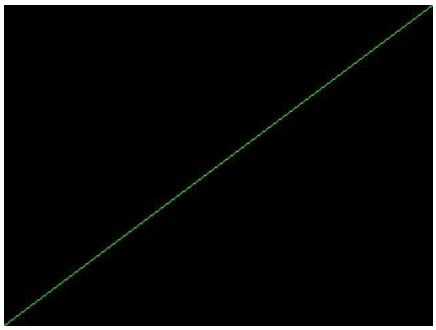
Drawing Lines

How about drawing lines? Let us try drawing a green line diagonally from one corner of the screen to the other. Here is the command format:

DRAW.LINE sx, sy, ex, ey, color		
Draws a line from sx, sy to ex, ey on the current drawing @SURFACE using color	sx	starting x coordinate (0 – 319)
	sy	starting y coordinate (0 – 240)
	ex	ending x coordinate (0 – 319)
	ey	ending y coordinate (0 – 240)
	color	RGB565 line pixels color

Here is the program:

```
10 REM Draw a green line from lower-left to upper-right
15 @ANSI.ENABLE=0
20 DRAW.FILL 0,0,320,240,RGB(0,0,0)
25 DRAW.LINE 0,0,319,239,RGB(0,255,0)
30 GOTO 30
```



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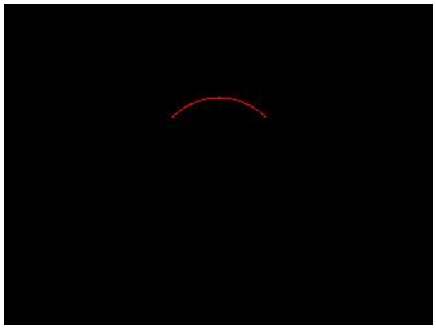
Drawing Arcs

How about drawing arcs? You could compute and draw each pixel making up the arc, or have ACS Basic draw it for you if you provide the center, width, height and starting/ending angles. Here is the command format:

DRAW.ARC x,y,width,height,start,end,color		
Draws an arc centered at x,y of width,height beginning at start angle and ending on end angle on the current drawing @SURFACE using color	x	center x coordinate (0 – 319)
	y	center y coordinate (0 – 240)
	width	arc width (0 – 319)
	height	arc height (0 – 240)
	start	starting angle (0 - 359)
	end	ending angle (0 – 359)
	color	RGB565 box pixels color

Here is the program:

```
10 REM draw a red 90 degree arc at the screen center
15 @ANSI.ENABLE=0
20 DRAW.FILL 0,0,320,240,RGB(0,0,0)
25 DRAW.ARC 160,120,100,100,45,135,RGB(255,0,0)
30 GOTO 30
```



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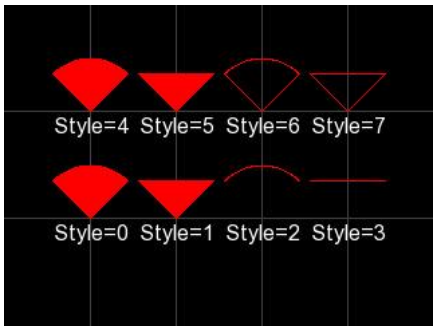
Drawing Arcs with Style

There is another arc drawing command that allows the arc to be 'styled'. Here is the command format:

DRAW.ARC.STYLED x,y,width,height,start,end,color,style	
Draws a 'styled' arc centered at x,y of width,height beginning at start angle and ending on end angle on the current drawing @SURFACE using color	x center x coordinate (0 – 319) y center y coordinate (0 – 240) width arc width (0 – 319) height arc height (0 – 240) start starting angle (0 - 359) end ending angle (0 – 359) color RGB565 box pixels color style combination of zero or more style bits that are 'or'ed together (0 – 7): 1 – Chord 2 – No Fill 4 - Edged

Here is a program to show the effect of the various combinations of the style bits:

```
10 REM arc demo
20 @ANSI.ENABLE=0
30 REM draw grid
40 FOR x = 64 TO 256 STEP 64 : DRAW.LINE x,0,x,239,RGB(64,64,64) : NEXT x
50 FOR y = 80 TO 160 STEP 80 : DRAW.LINE 0,y,319,y,RGB(64,64,64) : NEXT y
60 REM init text font
70 @FONT.HALIGN[0]=1 : @FONT.VALIGN[0]=2 : @FONT.FCOLOR[0]=RGB(255,255,255)
80 REM draw eight styles of filled arcs
90 DRAW.ARC.FILLED 64,80,80,80,45,135,RGB(255,0,0),0
100 DRAW.TEXT 0,64,80,"Style=0"
110 DRAW.ARC.FILLED 128,80,80,80,45,135,RGB(255,0,0),1
120 DRAW.TEXT 0,128,80,"Style=1"
130 DRAW.ARC.FILLED 192,80,80,80,45,135,RGB(255,0,0),2
140 DRAW.TEXT 0,192,80,"Style=2"
150 DRAW.ARC.FILLED 256,80,80,80,45,135,RGB(255,0,0),3
160 DRAW.TEXT 0,256,80,"Style=3"
170 DRAW.ARC.FILLED 64,160,80,80,45,135,RGB(255,0,0),4
180 DRAW.TEXT 0,64,160,"Style=4"
190 DRAW.ARC.FILLED 128,160,80,80,45,135,RGB(255,0,0),5
200 DRAW.TEXT 0,128,160,"Style=5"
210 DRAW.ARC.FILLED 192,160,80,80,45,135,RGB(255,0,0),6
220 DRAW.TEXT 0,192,160,"Style=6"
230 DRAW.ARC.FILLED 256,160,80,80,45,135,RGB(255,0,0),7
240 DRAW.TEXT 0,256,160,"Style=7"
999 GOTO 999
```



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Drawing Boxes

How about drawing boxes? You could compute and draw each line making up the box, or have ACS Basic draw it for you if you provide the locations of two diagonal corners. Here is the command format:

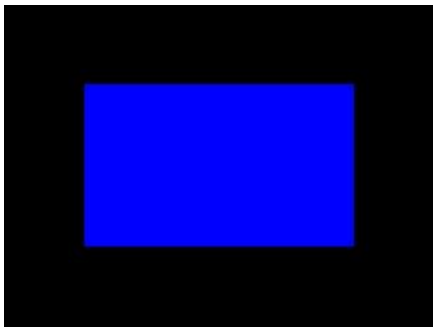
DRAW.BOX x1,y1,x2,y2,color	
Draws a box from diagonal corners x1,y1 to x2,y2 on the current drawing @SURFACE using color	x1 corner 1 x coordinate (0 – 319) y1 corner 1 y coordinate (0 – 240) x2 corner 2 x coordinate (0 – 319) y2 corner 2 y coordinate (0 – 240) color RGB565 box pixels color

Here is the program:

```
10 REM Draw a blue box around the screen edge
15 @ANSI.ENABLE=0
20 DRAW.FILL 0,0,320,240,RGB(0,0,0)
25 DRAW.BOX 0,0,319,239,RGB(0,0,255)
30 GOTO 30
```

and if you want a filled box:

```
10 REM Draw a blue box around the screen edge
15 @ANSI.ENABLE=0
20 DRAW.FILL 0,0,320,240,RGB(0,0,0)
25 DRAW.BOX.FILLED 60,60,260,180,RGB(0,0,255)
30 GOTO 30
```



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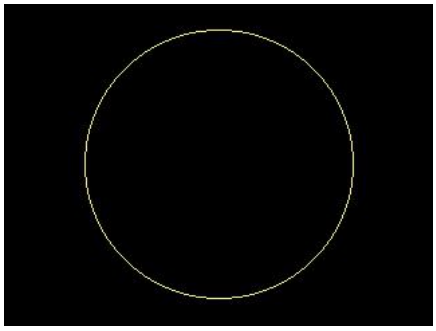
Drawing Circles

How about drawing a circle? Here is the command format:

DRAW.CIRCLE x,y,r,color	
Draws a circle of radius r centered at x, y on the current drawing @SURFACE using color	x center x coordinate (0 – 319) y center y coordinate (0 – 240) r circle radius(0 – 319) color RGB565 circle pixels color

and here is a program to draw a yellow circle centered on the screen:

```
10 REM Draw a blue box around the screen edge
15 @ANSI.ENABLE=0
20 DRAW.FILL 0,0,320,240,RGB(0,0,0)
25 DRAW.CIRCLE 160,120,100,RGB(255,255,0)
30 GOTO 30
```



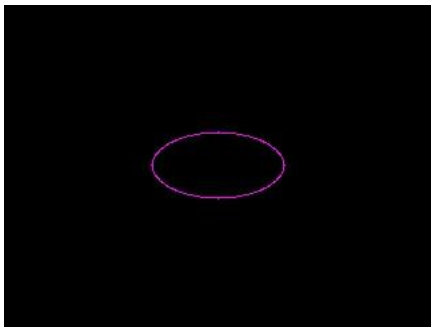
Drawing Ellipses

How about drawing an Ellipse? Here is the command format:

DRAW.ELLIPSE x, y, width, height, color	
Draws a width by height ellipse centered at x, y on the current drawing @SURFACE to color	x center x coordinate (0 – 319) y center y coordinate (0 – 240) width major axis width height minor axis width color RGB565 ellipse pixels color

and here is a program to draw a magenta ellipse centered on the screen:

```
10 REM Draw a blue box around the screen edge
15 @ANSI.ENABLE=0
20 DRAW.FILL 0,0,320,240,RGB(0,0,0)
25 DRAW.ELLIPSE 160,120,100,50,RGB(255,0,255)
30 GOTO 30
```



If you want a filled ellipse change line 25:

```
25 DRAW.ELLIPSE.FILLED 160,120,100,50,RGB(255,0,255)
```

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Drawing Polygons

A polygon is a flat shape consisting of straight lines that are joined to form a closed chain. A triangle is just a 3-sided polygon, a box is a 4-sided polygon with right angles between the sides. An N-sided polygon requires N coordinate pairs for its vertices.

How can we format a polygon draw command that can take a variable number of coordinates? The answer is to use an array of numbers to store each coordinate and just provide the array names to the polygon command.

Array variables are just a table of numbers or strings. In order to use an array you have to tell Basic how big of a table that you want. Basic then sets aside the correct amount of memory for that variable to hold the number of values that you require. In computer terminology this is referred to as ***dimensioning an array***. Basic provides a DIMension command for this purpose:

```
30 DIM x[3],y[3]
```

When you access the individual values in this array you specify an index into the table to select which value that you want. The index follows the variable name and is enclosed in brackets [ ]. Here is a conceptual picture of what a 5 element numeric array looks like. Notice that there are 5 elements, numbered 0 – 4:

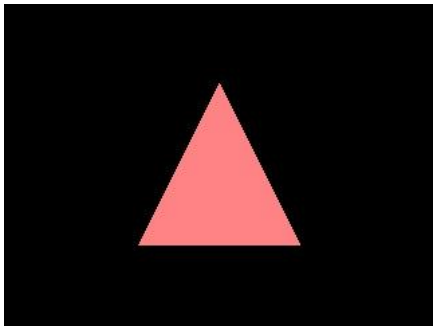
DIM Variable[5]		values
	0	
	1	
Variable[2] →	2	
	3	
	4	

Since each array variable holds a single set of values, to draw a polygon you will need two arrays: one for the X coordinates of each vertex and one for the Y coordinates. Your program 'fills' these arrays with the coordinates for each point – prior to calling the DRAW.POLYGON command. The command looks at the dimensioned size of these coordinate arrays to determine how many sides (and vertices) that the polygon should be drawn with.

So let us draw a 3-sided polygon – a triangle – centered on the screen. We need X and Y coordinate arrays that each hold 3 values. Here is the program:

```
10 REM Draw a triangle
20 @ANSI.ENABLE=0
30 DIM x[3],y[3] : REM Allocate coordinate arrays
40 DRAW.FILL 0,0,320,240,RGB(0,0,0)
50 REM Load x & y coordinates
60 x[0]=100:y[0]=60:x[1]=220:y[1]=60:x[2]=160:y[2]=180
70 DRAW.POLYGON x,y,RGB(255,128,128)
80 GOTO 80
```

And you can also fill it in – change the DRAW.POLYGON command to DRAW.POLYGON.FILLED.



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Drawing Text

Let us say that we need to put text on the screen along with our graphics. You could leave the @ANSI.ENABLE system variable set to one, and use PRINT commands. How do you control where the text appears on the screen?

The @ANSI command has a few additional modifiers – two of which allow you to read the current ANSI row and column values, or set them before printing: @ANSI.ROW and @ANSI.COL. The ANSI rows and columns are numbered like this starting in the upper left of the screen:

	Col 0	Col 1	Col 2	…	Col 42	Col43	Col 44
Row 0							
Row 1				…			
Row 2							
…				…			
Row 17							
Row 18				…			
Row 19							

Try it out – PRINT Hello in the middle of the screen:

```
@ANSI.ROW = 10 : @ANSI.COL = 17 : PRINT “Hello!”
```

While this does work – there are a few problems. The cursor appears, blinking, on the screen – which you may not want. You can turn this off with another @ANSI command:

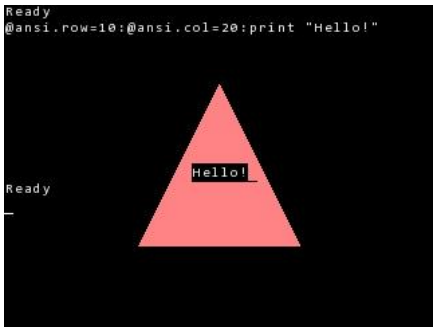
```
@ANSI.CURSOR = 0 : REM Turn off ANSI cursor
```

And, if you PRINT on the bottom line of the screen without a trailing semi-colon – or if the text wraps to the next line the screen will scroll up. You can turn these features off with another couple @ANSI commands:

```
@ANSI.WRAP = 0 : REM Turn off ANSI line wrap
```

```
@ANSI.SCROLL = 0 : REM Turn off ANSI screen scrolling
```

While this method of drawing text can be made to work, the positioning is coarse, the characters are always white on black, and you are stuck with the character height and style that ANSI operation uses. We’ll examine an alternative text display method next which uses another DRAW command along with some additional system commands to control the text appearance.



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Drawing Text with Style

The shape, appearance and size of drawn text characters specify the text's style. In computer terminology the style of text is referred to as a ***font***. ACS Basic provides support for up to 32 different fonts to be in use at a time. Each of the 32 fonts can be configured by your program to change the text color, relative position and appearance. The entries in this font table are accessed through system variables. The individual character shapes and their size are obtained from another table in memory by their name – these are the actual embedded fonts. The two pieces of information: the embedded font to use and how it is colored and positioned are selected as an entry in the font table used to draw the desired text. In computer terminology this is referred to as ***rendering text***.

The embedded fonts must be loaded into the device's memory in order to be used for drawing text. They are stored in a collection with other items where they can be quickly accessed by their name.

It is a Matter of Resources

In the ACS products that support Basic Graphics commands there are a collection of fonts and other objects that the Basic can draw with – they are collectively known as Resources. The Color LCD 320x240 Terminal first looks for resources to load in an on-board flash memory. Both the Color LCD and CFSound-IV look for resources to load on the SD card installed by trying to load a binary file named Resources.bin .

You can list the resources that are currently loaded, the command is RESOURCES.LIST. Here is what the list would look like if no additional resources could be found and loaded at power-up:

```
resources.list
AcsAnsiFont.efnt                    12,604 builtin
AcsDefaultFont.efnt                 27,940 builtin
ButtonK.bmp                          1,610 builtin
ButtonK2.bmp                         2,050 builtin
ButtonK4.bmp                         3,018 builtin
ButtonM.bmp                          2,618 builtin
Ready
```

There are a few resources that are built-in: they are required to allow the status, Configuration Settings screen and other features to operate if no additional resources can be found. The files with the .EFNT extension are 'embedded font files'. They contain the information about the size and shape of the text characters for drawing purposes. The AcsAnsiFont.efnt file is used for PRINTing ANSI text, the AcsDefaultFont.efnt is used for displaying the power-up status messages and labeling the keys on the Configuration Settings keypad.

There is a Windows utility that can be used to generate these embedded font files from existing computer font files – you select the computer font, what size to make it, what characters to include in the font and what name to give the generated .EFNT file and the utility generates the file. This is described in an Appendix of this manual.

How do you get your embedded font files into the product resources? You can then place the embedded font file on the SD card and load it into the resources manually or in your program using the RESOURCES.ADD command:

```
resources.add ComicSansBold14.efnt
Ready
resources.list
ComicSansBold14.efnt                25,666
AcsAnsiFont.efnt                    12,604 builtin
AcsDefaultFont.efnt                 27,940 builtin
ButtonK.bmp                          1,610 builtin
ButtonK2.bmp                         2,050 builtin
ButtonK4.bmp                         3,018 builtin
ButtonM.bmp                          2,618 builtin
Ready
```

So there are at least two embedded font files to work with that are built-in. How can we use these to draw text on the screen? Let us look using the FONTS commands.

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There is a Table of Fonts

Just like with the resources, there is a FONTS.LIST command. Try it:

```
fonts.list
F#, "Resource Name                ", BCOLOR         , FCOLOR         , SPACINGX, SPACINGY, HALIGN, VALIGN, BTRANS, FTRANS
 0, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(255,255,255),        0,        0,      1,      1,      1,      0
 1, "AcsAnsiFont.efnt             ", RGB(  0,  0,  0), RGB(255,255,255),        0,        0,      0,      1,      1,      0
 2, "AcsAnsiFont.efnt             ", RGB(255,255,255), RGB(  0,  0,  0),        0,        0,      0,      1,      0,      0
 3, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(  0,  0,  0),        0,        0,      1,      0,      1,      0
 4, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(255,255,255),        0,        0,      0,      0,      1,      0
 5, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(255,255,255),        0,        0,      1,      1,      1,      0
 6, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(255,255,255),        0,        0,      1,      1,      1,      0
 7, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(  0,  0,  0),        0,        0,      1,      1,      1,      0
 8, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(255,255,255),        0,        0,      1,      1,      1,      0
 9, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(  0,  0,  0),        0,        0,      1,      1,      1,      0
10, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(255,255,255),        0,        0,      1,      1,      1,      0
11, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(  0,  0,  0),        0,        0,      1,      1,      1,      0
12, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(255,255,255),        0,        0,      1,      1,      1,      0
13, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(  0,  0,  0),        0,        0,      1,      1,      1,      0
14, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(255,255,255),        0,        0,      1,      1,      1,      0
15, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(  0,  0,  0),        0,        0,      1,      1,      1,      0
16, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(255,255,255),        0,        0,      1,      1,      1,      0
17, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(  0,  0,  0),        0,        0,      1,      1,      1,      0
18, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(255,255,255),        0,        0,      1,      1,      1,      0
19, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(  0,  0,  0),        0,        0,      1,      1,      1,      0
20, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(255,255,255),        0,        0,      1,      1,      1,      0
21, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(  0,  0,  0),        0,        0,      1,      1,      1,      0
22, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(255,255,255),        0,        0,      1,      1,      1,      0
23, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(  0,  0,  0),        0,        0,      1,      1,      1,      0
24, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(255,255,255),        0,        0,      1,      1,      1,      0
25, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(  0,  0,  0),        0,        0,      1,      1,      1,      0
26, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(255,255,255),        0,        0,      1,      1,      1,      0
27, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(  0,  0,  0),        0,        0,      1,      1,      1,      0
28, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(255,255,255),        0,        0,      1,      1,      1,      0
29, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(  0,  0,  0),        0,        0,      1,      1,      1,      0
30, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(255,255,255),        0,        0,      1,      1,      1,      0
31, "AcsDefaultFont.efnt          ", RGB(  0,  0,  0), RGB(  0,  0,  0),        0,        0,      1,      1,      1,      0
Ready
```

What are all of these numbers? The first column is the ‘font number’ – the index into the font table. In Basic you can treat this table as an array using an index to access individual rows.

The second column is the embedded font file name in the resources that will be used to render text using this font table entry. Note that when setting the .efnt resource to be used by an entry, that entry has to exist in the resources – if it doesn’t an error will occur.

The next two columns indicate what Background color (BCOLOR) and Foreground color (FCOLOR) will be used when rendering the text. The FCOLOR is the color of the actual character pixels, the BCOLOR is the color of the pixels surrounding the character. The values in the table are 16-bit RGB565 values – they are shown in the listing as if they were set using the RGB( ) function – which they can be.

The next four columns control the relative positioning of the characters when text is rendered with this font entry. The SPACINGX column controls the spacing between characters of the font. A value of ‘0’ will use the fixed width of the font to place the following character. A ‘-1’ will use the “bounding box” character width for horizontal spacing. A non-zero, positive value will force that spacing character to character when fonts are oriented horizontally.

The SPACINGY column works in the same way but affects vertical spacing when fonts are oriented vertically. (this operation is not currently supported)

The ALIGN columns control the relative placement of the drawn text relative to the starting coordinate provided the DRAW.TEXT command – or the text alignment to the coordinates. The HALIGN entry controls the horizontal alignment: a value of ‘0’ justifies the text from the left, a value of ‘1’ centers the text and a value of ‘2’ justifies the text from the right. The VALIGN entry controls the vertical alignment: a value of ‘0’ justifies the text from the top, a value of ‘1’ centers the text and a value of ‘2’ justifies the text from the bottom.

The last two columns control the transparency of the rendered text. A transparent pixel is not drawn with the result that anything it is drawn on top of will ‘show through’. The BTRANS column controls the character background pixels and the FTRANS column controls the foreground pixels. A value of ‘0’ forces those pixels to be drawn, a value of ‘1’ forces those pixels to not be drawn.

All of these font table entries may be accessed – read / written using system variables – specifying an index of the entry:

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System Variable	Values	Description
@FONT.EFNT$[entry]	"resource.efnt"	Gets/Sets embedded font resource for entry – the resource must exist in the resource table to set
@FONT.BCOLOR[entry]	RB565 pixel color	Gets/Sets font background color for entry – use RGB( ) to set
@FONT.FCOLOR[entry]	RB565 pixel color	Gets/Sets font foreground color for entry – use RGB( ) to set
@FONT.SPACINGX[entry]	-1 = bounding box 0 = fixed width >0 = spacing	Gets/Sets font horizontal spacing
@FONT.SPACINGY[entry]	-1 = bounding box 0 = fixed width >0 = spacing	Gets/Sets font vertical spacing (not currently supported)
@FONT.HALIGN[entry]	0 = left justify 1 = center justify 2 = right justify	Gets/Sets font horizontal alignment
@FONT.VALIGN[entry]	0 = top justify 1 = center justify 2 = bottom justify	Gets/Sets font vertical alignment
@FONT.BTRANS[entry]	0 = normal 1 = transparent	Gets/Sets font background transparency
@FONT.FTRANS[entry]	0 = normal 1 = transparent	Gets/Sets font foreground transparency

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And Now Back to Drawing the Text

So now we can get back to the DRAW.TEXT command. As with the other commands here is the command format:

DRAW.TEXT f, x, y, expr		
Renders the expression on the current drawing @SURFACE relative to x, y using the font table entry f values	f	font table entry number (0 – 31)
	x	justification x coordinate (0 – 319)
	y	justification y coordinate (0 – 240)
	expr	the number or string to draw

So let us try this out. There is already some default entries in the font table. What if we write a simple program that draws "Hello!" in the center of the screen using Font zero:

```
10 REM Draw text
20 @ANSI.ENABLE=0
30 DRAW.TEXT 0,160,120,"Hello!"
40 GOTO 40
```

Let us make the font red; set Font zero's foreground color to red before drawing the text:

```
10 REM Draw red text
20 @ANSI.ENABLE=0
25 @FONT.FCOLOR[0]=RGB(255,0,0)
30 DRAW.TEXT 0,160,120,"Hello!"
40 GOTO 40
```

What do all of these alignment options do – there are nine combinations. Here is a program to show you how the @FONT.HALIGN and @FONT.VALIGN system variables control the relative text positioning. First we draw a grid using DRAW.LINE commands, then we DRAW.TEXT at the grid intersection points with the various font alignment options to show how they affect the text rendering:

```
5 REM Test font HALIGN and VALIGN
10 @ANSI.ENABLE=0
20 REM Draw grid
30 DRAW.LINE 10,0,10,239,RGB(255,0,0)
40 DRAW.LINE 160,0,160,239,RGB(255,0,0)
50 DRAW.LINE 309,0,309,239,RGB(255,0,0)
60 DRAW.LINE 0,10,319,10,RGB(255,0,0)
70 DRAW.LINE 0,120,319,120,RGB(255,0,0)
80 DRAW.LINE 0,229,319,229,RGB(255,0,0)
90 REM Draw aligned text
100 @FONT.HALIGN[0]=0:@FONT.VALIGN[0]=0:DRAW.TEXT 0,10,10,"LEFT,BOT"
110 @FONT.HALIGN[0]=1:@FONT.VALIGN[0]=0:DRAW.TEXT 0,160,10,"MID,BOT"
120 @FONT.HALIGN[0]=2:@FONT.VALIGN[0]=0:DRAW.TEXT 0,309,10,"RIGHT,BOT"
130 @FONT.HALIGN[0]=0:@FONT.VALIGN[0]=1:DRAW.TEXT 0,10,120,"LEFT,MID"
140 @FONT.HALIGN[0]=1:@FONT.VALIGN[0]=1:DRAW.TEXT 0,160,120,"MID,MID"
150 @FONT.HALIGN[0]=2:@FONT.VALIGN[0]=1:DRAW.TEXT 0,309,120,"RIGHT,MID"
160 @FONT.HALIGN[0]=0:@FONT.VALIGN[0]=2:DRAW.TEXT 0,10,229,"LEFT,TOP"
170 @FONT.HALIGN[0]=1:@FONT.VALIGN[0]=2:DRAW.TEXT 0,160,229,"MID,TOP"
180 @FONT.HALIGN[0]=2:@FONT.VALIGN[0]=2:DRAW.TEXT 0,309,229,"RIGHT,TOP"
190 GOTO 190
```

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Drawing Images

Using all of the DRAWing command you can construct pretty line art displays. But how do we draw images – like photos or Photoshop generated graphics?

There is a DRAW.BITMAP command that will allow you to do this. While it is simple to use there are a few caveats:

1. The image to be drawn on the screen must be a Windows .BMP bitmap file.
2. The image must be resident in the device's memory by being a Resource in the Resource table.

To quickly try this command we'll use one of the built-in image resources. Use a RESOURCES.LIST command with a wildcard name pattern to list all of the image resources:

```
resources.list *.bmp
ButtonK.bmp  1,610 builtin
ButtonK2.bmp 2,050 builtin
ButtonK4.bmp 3,018 builtin
ButtonM.bmp  2,618 builtin
Ready
```

The names suggest that these are images of the buttons that the device uses for the Configuration Settings screen keyboard. They have to be 'built-in' so that they are always there – even when no other resources are loaded.

So let us draw one of the button images in the center of the screen. As before here is the command format from the Reference:

DRAW.BITMAP x, y, imageResourceName		
Renders the bitmap resource on the current drawing @SURFACE at x, y	x	image lower-left x coordinate (0 – 319)
	y	image lower-left y coordinate (0 – 240)
	imageResourceName	the string name of the loaded image resource to draw

Type the following commands – first let us clear the screen:

```
draw.fill 0,0,320,240,RGB(0,0,0)
```

This leaves the Ready prompt and blinking cursor at the top of the screen – OK for now. Now let us draw the ButtonK4.bmp image at the center of the screen. Type the following command:

```
draw.bitmap 160,120,"ButtonK4.bmp"
```

Your screen should now look like:

Surprise! The image looks like the Configuration Settings screen keypad spacebar – without any colors.

Why isn't it shown in the center of the screen at 160, 120? This is because the DRAW.BITMAP coordinates reference where the lower-left corner of the bitmap image will be drawn. The ButtonK4.bmp happens to be 88 pixels wide by 22 pixels tall. So we could center it by subtracting half of these values from the x and y coordinates. Let us try moving it - type the following command:

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```
draw.bitmap 160-88/2,120-22/2,"ButtonK4.bmp"
```

Your screen should now look like:

Notice that it is centered now, and also that it was drawn on top of what was already there – like stacking photos. The effect of all of the DRAW commands is cumulative – each one builds upon the resulting image.

There are additional variations on the DRAW.BITMAP command that support transparency and indexing. These are outlined in the ACS Basic Reference section of this manual.

Rules for Drawing

1. DRAWing commands use x (horizontal) and y (vertical) coordinates to control where they affect the screen.
2. Graphic DRAWing commands specify the color to use with a 16-bit additive RGB color model – expressed with a signed integer value or using the RGB(red,green,blue) function.
3. The DRAW.POLYGON commands require arrays of the x and y coordinates of the polygon vertices. The arrays must be pre-DIMensioned and loaded with the vertex coordinates before the polygon can be drawn.
4. The DRAW.TEXT command uses embedded font file (.EFNT) resources to render the text on the screen. The style, color, alignment and transparency of the drawn text are controlled by referring to a configured entry in the FONTS table.
5. The DRAW.BITMAP commands render Windows .BMP image resources on the screen. The x and y coordinates refer to the placement of the lower-left corner of the image resource on the screen.
6. Drawing is cumulative – each successive DRAW command builds on the results of prior commands.

Making Things Move

So we know how to make static screens using the DRAW commands. How do we make something that moves?

Let us draw a simple old-style sonar screen – like the ones used on submarines. It consisted of a circle and a sweeping line that rotated from the center. We know how to clear the screen, draw the circle and line, but how do we make the line rotate around the circle? We know the circle's center coordinate would be the line's starting point, but how to we dynamically compute the rotating line's end coordinate? For that we need to use some mathematics.

Warning – Mathematics

In mathematics, the trigonometric functions (also called circular functions) are functions of an angle. They are used to relate the angles of a triangle to the lengths of the sides of a triangle.

The most familiar trigonometric functions are the sine and cosine. In the context of the standard unit circle with radius 1, where a triangle is formed by a ray originating at the origin and making some angle with the x-axis, the sine of the angle gives the length of the y-component (rise) of the triangle and the cosine gives the length of the x-component (run). Trigonometric functions are commonly defined as ratios of two sides of a right triangle containing the angle, and can equivalently be defined as the lengths of various line segments from a unit circle.

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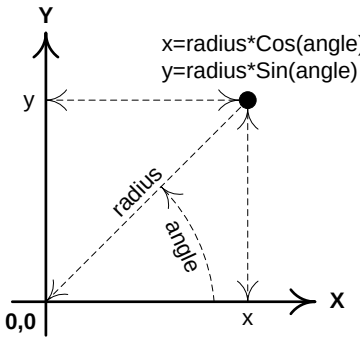
Here is a drawing showing this relationship:



As we saw earlier in the ACS Basic User's Manual section on functions, Basic has both SIN( ) and COS( ) functions. These trig functions take an angle argument and return the unit circle ratios – up scaled by 1024 since this Basic only provides integer math.

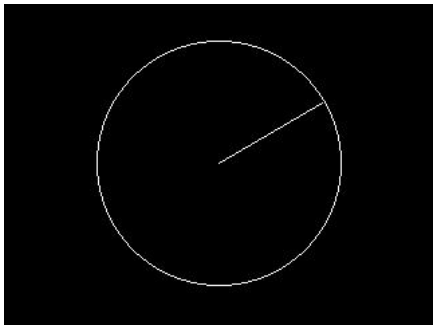
In order to perform the radius multiplication and subsequent down scaling by 1024 the MULDIV( ) function is used. This function multiplies the first two arguments as 32-bit integers and then divides by the third argument to return a 16-bit result.

We now have the pieces we need to draw our sweeping sonar screen. To rotate the line we un-draw it at its old angle then redraw it at the new angle as we sweep the angle through 360 degrees.

Here is the program:

```
10 REM Sonar Sweep
20 @ANSI.ENABLE=0:@BACKLIGHT=1
30 centerX = 160 : centerY = 120 : radius = 90
40 DRAW.FILL 0,0,320,240,RGB(0,0,0)
50 DRAW.CIRCLE centerX, centerY, radius, RGB(255,255,255)
60 FOR angle = 0 TO 359
70 lineX = MULDIV(radius-1, COS(angle), 1024)
80 lineY = MULDIV(radius-1, SIN(angle), 1024)
90 DRAW.LINE centerX, centerY, centerX + oldLineX, centerY + oldLineY, RGB(0,0,0)
100 DRAW.LINE centerX, centerY, centerX + lineX, centerY + lineY, RGB(255,255,255)
110 oldLineX = lineX : oldLineY = lineY
120 NEXT angle
130 GOTO 60
Ready
```

And here is what your display should look like – with the sweep line rotating counter-clockwise around the circle origin:



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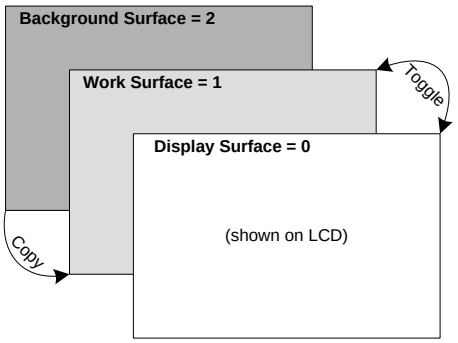
Moving Smarter

While this program works, there is a lot of flickering of the sweep line and we have to keep track of the line's old position so that we can un-draw it before redrawing it in its new position. There is a better way using an approach called ping-pong or double buffering.

With double buffering, drawing alternates between two different surfaces – one is shown while drawing on the other, then they are switched and the process repeats.

The ACS Basic Graphics actually has three drawing surfaces to support this approach: Display, Work and Background:



The Background surface provides a content area that can be seldom drawn, and copied to the Work surface before additional drawing is done on top.

The Work surface is where most drawing is done before being swapped with the Display surface.

The Display surface is the one that is currently being shown on the screen. This is the one that we have been drawing on up to now.

All of the DRAW commands operate on the current drawing surface which is set using a system variable - @SURFACE. The DRAW.TOGGLE command is used to swap the Work and Display surfaces – they aren't copied, the Work surface becomes the Display and the old Display becomes the Work surface.

In order to implement double buffering and avoid flickering as the display is updated we need to change our program to use the following sequence:

Double-Buffering Sequence

1. Switch to the Background draw surface.
2. Draw any required static background content.
3. Switch to the Work surface.
4. Copy in the content from the Background surface to the Work surface and draw any dynamic content on top of it.
5. Toggle the Work and Display surfaces.
6. Repeat from step 4.

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Let us modify the sonar sweep program to use this double buffering approach.

Here is the DRAW.COPY command format from the reference:

DRAW.COPY src,sx,sy,dx,dy,w,h	
Copies the width x height bitmap from the src surface @ sx,sy on the current drawing @SURFACE at dx, dy	src source surface number (0, 1, 2) sx source lower-left x coordinate (0 – 319) sy source lower-left y coordinate (0 – 240) dx destination lower-left x coordinate (0 – 319) dy destination lower-left y coordinate (0 – 240) w width of area to copy (1 – 320) h height of area to copy (1 – 240)

First we'll select the background surface, clear it and draw in the circle – which is static – it doesn't change:

```
@SURFACE=2
DRAW.FILL 0,0,320,240,RGB(0,0,0)
DRAW.CIRCLE centerX, centerY, radius, RGB(255,255,255)
```

Next we'll select the work surface:

```
@SURFACE=1
```

Then we copy the background surface area encompassing the circle and draw the sweep line on it:

```
DRAW.COPY 2, leftX, leftY, leftX, leftY, width, height
lineX = MULDIV(radius-1, COS(angle), 1024)
lineY = MULDIV(radius-1, SIN(angle), 1024)
DRAW.LINE centerX, centerY, centerX + lineX, centerY + lineY, RGB(255,255,255)
```

Finally we toggle the Work and Display surfaces then rinse and repeat.

```
DRAW.TOGGLE
```

Here is the complete modified sonar sweep program that now uses the double buffering approach – run it and notice that the flickering is gone:

```
10 REM Sonar Sweep
20 @ANSI.ENABLE=0 : @BACKLIGHT=1
30 centerX = 160 : centerY = 120 : radius = 90
40 leftX=centerX-(radius+1) : leftY=centerY-(radius+1) : width=(radius+1)*2 : height=(radius+1)*2
50 @SURFACE=2
60 DRAW.FILL 0,0,320,240,RGB(0,0,0)
70 DRAW.CIRCLE centerX, centerY, radius, RGB(255,255,255)
80 @SURFACE=1
90 FOR angle = 0 TO 359
100 DRAW.COPY 2, leftX, leftY, leftX, leftY, width, height
110 lineX = MULDIV(radius-1, COS(angle), 1024)
120 lineY = MULDIV(radius-1, SIN(angle), 1024)
130 DRAW.LINE centerX, centerY, centerX + lineX, centerY + lineY, RGB(255,255,255)
140 DRAW.TOGGLE
150 NEXT angle
160 GOTO 90
```

Notice that the circle is only drawn once – in fact it could be a bitmap image. Add the ButtonK4.bmp image into the background screen:

```
75 draw.bitmap centerX-88/2,centerY-22/2,"ButtonK4.bmp"
```

Save and run it again. You should see the sweep line rotating on top of the button:

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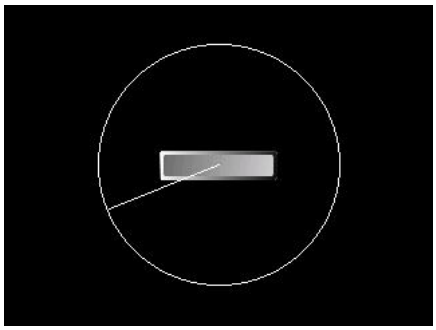

Changing Direction

The last example ran the animation at full speed – there was no delay between screen updates and the angle was incremented through an entire circle of 360 degrees in one degree steps.

What if you wanted to simulate the second hand of a clock? A few changes would be necessary; the motion should only occur once per second, the rotation would have to move clockwise instead of counter-clockwise, and since there are 60 seconds around the face of a clock the motion would have to advance:

$$\frac{360\ degrees}{60\ seconds} = 6\frac{degrees}{second}$$

Also – zero seconds is straight up to the 12 o'clock position – which is not the zero angle position but 90 degrees.

Let us start by tackling the non-zero angle for zero seconds and the clockwise motion. Remember from the earlier mathematics section that the angle advances counter-clockwise as the angle increases. If you change line 90 in the previous program to STEP the FOR/NEXT loop from 359 to 0 and run the program you will see that the motion is now in the clockwise direction. If you change the STEP value from -1 to -6 the motion is faster, but still in a clockwise direction.

So how can we translate the seconds to the required negative angle with the 90 degree offset? Let us start by offsetting the zero angle from the 360 degree position by 90 degrees – 360 + 90 = 450 degrees. From the previous equation and results we know that we have to subtract 6 degrees per second:

```
angle = (360 + 90) - (second * 6)
```

This equation yields angle = 450 when second = 0, and angle = 96 when second = 59. We need a way to limit the range of the computed angle to 0 – 359 degrees for use with the SIN( ) and COS( ) functions.

Enter the modulus operator: %. Integer division truncates (discards) the fractional part of the result. The modulus operator divides the value to its left by the value on its right and returns the remainder. When both values are equal or integer multiples, the remainder of the division is zero. This can be evaluated as:

x % y = (x – ((x / y) * y))

Try computing the modulus of 4 for various values:

0 % 4	= (0 – ((0/4) * 4))	= 0
1 % 4	= (1 – ((1/4) * 4))	= 1
2 % 4	= (2 – ((2/4) * 4))	= 2
3 % 4	= (3 – ((3/4) * 4))	= 3
4 % 4	= (4 – ((4/4) * 4))	= 0
5 % 4	= (5 – ((5/4) * 4))	= 1
6 % 4	= (6 – ((6/4) * 4))	= 2

You can see that the modulus ranges from zero when the arguments are equal to one less than the modulus. So taking the modulus 360 of the angle computation returns an angle between 0 and 359:

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```
angle = ((360 + 90) - (second * 6) % 360)
```

If you now change lines 90 and 150 to count seconds from 0 to 59 and add line 95 to compute the angle you will see the motion being driven counter-clockwise in 6 degree increments as the seconds range from 0 to 59.

Rules for Making Things Move

1. To avoid flickering when moving graphics by DRAWing, use the double-buffering sequence.
2. You can compute the X and Y coordinates for DRAWing circular motion using the trig functions SIN( ) and COS( ) and scale the results using the MULDIV( ) function.
3. Incrementing angles rotate counter-clockwise, decrementing angles rotate clockwise.
4. The modulus operator % returns the remainder of the division of the two arguments.

Staging an Event

We could add a 1 second delay using a @TIMER system variable and increment the second variable from zero through fifty-nine every time that we read @TIMER is zero. There is another way that will allow our program to do other things instead of simply spinning in a loop waiting on a timer. Welcome to Events.

Events are changes in your program's execution that can happen in between each statement. The linear execution of your program's statements is interrupted to process the event and then execution resumes from where your program was interrupted. Events are associated with and triggered by some system variables and can occur as a result of hardware or software actions.

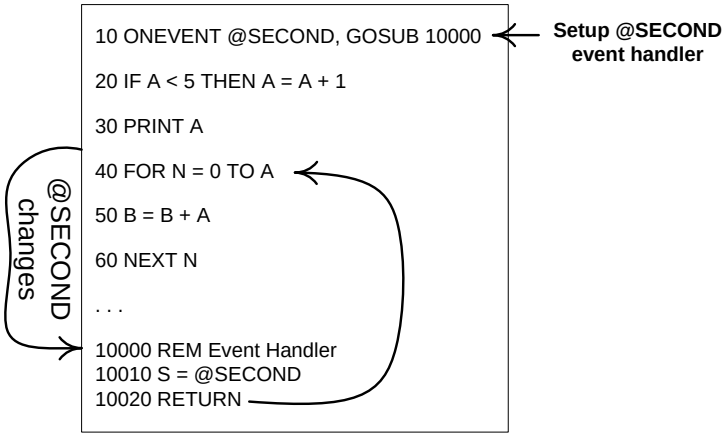
You control how system variable events are processed in your program by associating them with an event handler. The event handler is a subroutine you write that will be called when the event is signaled by changes in the associated system variable.

The event handler is configured or setup using the ACS Basic's ONEVENT command:

```
ONEVENT @systemvariable, GOSUB linenumber
```

This command records the handler subroutine line number in an event table for the specified system variable entry. Changes to system variables that cause events set a flag on their entry in the event table.

In between processing each program statement Basic scans the event table looking for flagged entries. When a flagged entry is found Basic performs the GOSUB to the recorded event handler line number. When the event handler subroutine returns, Basic clears the flagged entry.


10 ONEVENT @SECOND, GOSUB 10000
Setup @SECOND event handler
20 IF A < 5 THEN A = A + 1
30 PRINT A
40 FOR N = 0 TO A
50 B = B + A
60 NEXT N
. . .
10000 REM Event Handler
10010 S = @SECOND
10020 RETURN
@SECOND changes

Events are prioritized – an executing event handler can only be interrupted by a higher priority event.

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It is important to remember that all variables are shared between all parts of your program. If your program is performing some long calculation using a variable and you change that variable in an event handler your program may get confused or generate incorrect results since the event handler can potentially execute anywhere in your program after it is configured.

So let us add event processing to our second hand program. There is a system variable @SECOND that is updated once a second from the device's Real Time Clock hardware. It signals an event when this happens. We will turn the program lines 95 – 160 into a @SECOND event handler.

Edit line 95 to change the second to the @SECOND system variable in the angle calculation:

```
95 angle = ((360 + 90) - @SECOND * 6) % 360
```

Change line 150 to a RETURN statement and remove line 160. Now add line 85 to configure the @SECOND event handler to call the new subroutine at line 95:

```
85 ONEVENT @SECOND,GOSUB 95
```

And, just to show that your program is capable of doing other things while updating the screen once a second replace line 90 with:

```
90 a = a + 1 : PRINT a : GOTO 90
```

Your program should now look like:

```
 10 REM Sonar Sweep
20 @ANSI.ENABLE=0:@BACKLIGHT=1
30 centerX = 160 : centerY = 120 : radius = 90
40 leftX = centerX-(radius+1) : leftY = centerY-(radius+1) : width = (radius+1)*2 : height = radius+1)*2
50 @SURFACE=2
60 DRAW.FILL 0,0,320,240,RGB(0,0,0)
70 DRAW.CIRCLE centerX, centerY, radius, RGB(255,255,255)
75 DRAW.BITMAP centerX-88/2,centerY-22/2,"ButtonK4.bmp"
80 @SURFACE=1
85 ONEVENT @SECOND,GOSUB 95
90 a = a + 1 : PRINT a : GOTO 90
95 angle = ((360 + 90) - @SECOND * 6) % 360
100 DRAW.COPY 2,leftX,leftY,leftX,leftY,width,height
110 lineX = MULDIV(radius-1, COS(angle), 1024)
120 lineY = MULDIV(radius-1, SIN(angle), 1024)
130 DRAW.LINE centerX, centerY, centerX + lineX, centerY + lineY, RGB(255,255,255)
140 DRAW.TOGGLE
150 RETURN
```

If you run this program, you will see the line rotating like a second hand – clockwise, 6 degrees every second. At the same time, your program is PRINTing an incrementing number.

Rules for Events

1. Events are interruptions to your program's normal flow of execution caused by hardware or software changes to system variables.
2. To process events you create an association between a system variable and a subroutine in your program using the ONEVENT command. The subroutine will be executed when the event is signaled by a change to the system variable. The event is cleared by the RETURN from the event.
3. You can disable further event handling for a system variable by executing an ONEVENT command with a line number of zero.
4. Variables are shared between your mainline program and any event handlers. Care should be exercised to ensure that inadvertent changes to variables in an event handler don't affect your main program logic.
5. Events are prioritized - only higher priority events able to interrupt an executing event handler.
6. Event handlers should be short so that lower priority events have a chance to occur.

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Taking Control with the Screen Framework

By now you can probably see how you could use the DRAWing commands to construct some pretty fancy screens with animation.

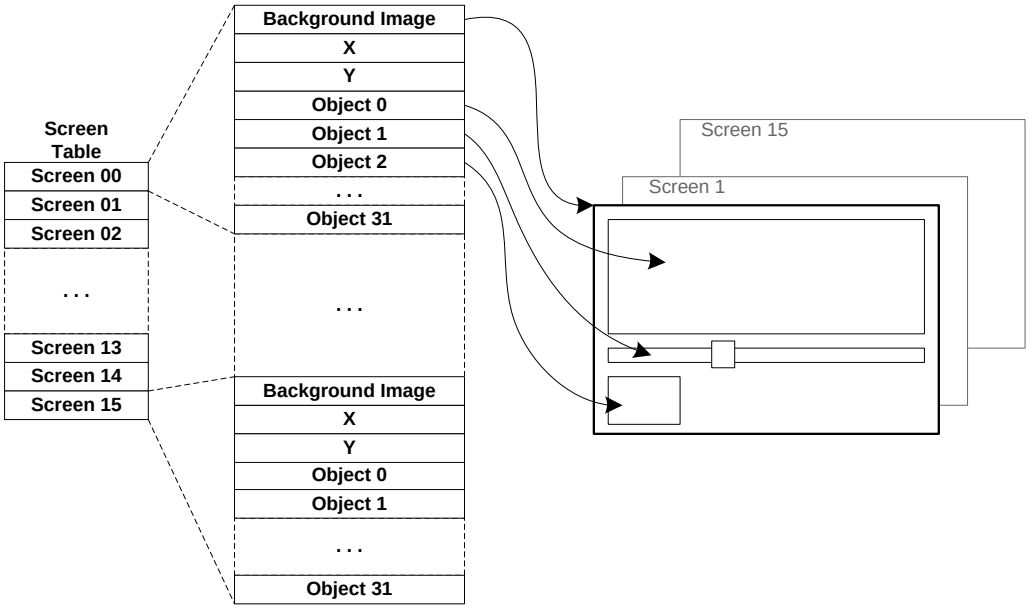
There is another method available to provide multiple screens, each with multiple controls – controls that provide a higher level of functionality and take care of drawing themselves and interacting with the user. This is accomplished using a built-in ACS Basic Screens Framework providing commands and system variables to interact with.

There is a Table of Screens

Earlier we saw how embedded fonts and bitmap images were accessed using Resources and the Font table. The Screens Framework adds two more tables to the mix; a Screen table and a Scheme table.

The Screen table holds information about how to draw each Screen entry and what controls (Screen Objects) each Screen uses. The Screen table currently holds sixteen Screen entries, and each Screen entry currently holds up to thirty-two Screen Object entries.

Screen Object entries define what type of object (button, slider, gauge, label, etc.), how it is rendered (images, scheme, text, options), where it is positioned in relationship to the containing screen, what 'value' it has and other information used to interact with the user and running program. Here is a diagram:



ACS Basic has system variables to access the elements of the Screen table and commands to persist and 'navigate' the table – saving and loading the table and what screen entry to change to, push to or pop from. Screens are not stored fully rendered in memory but are 'constructed' (drawn) when navigated to.

Scheming Controls

The Schemes table holds information about how to draw and colorize images and display text.

Screen Objects can reference Scheme table entries to control how they are drawn and colored as well as how any text that they display is rendered. Scheme table entries are usually used in pairs with the lower-numbered entry used to render an un-touched control and the higher-numbered entry used to render a control that is touched. In the previous section we drew a built-in keypad button bitmap that was drawn as grayscale – only shades of black to white were used. The Screens Framework's use of schemes allows these buttons and their text to be colorized – and the color to change as the buttons are pressed and released. This provides an easy way to accomplish a common look

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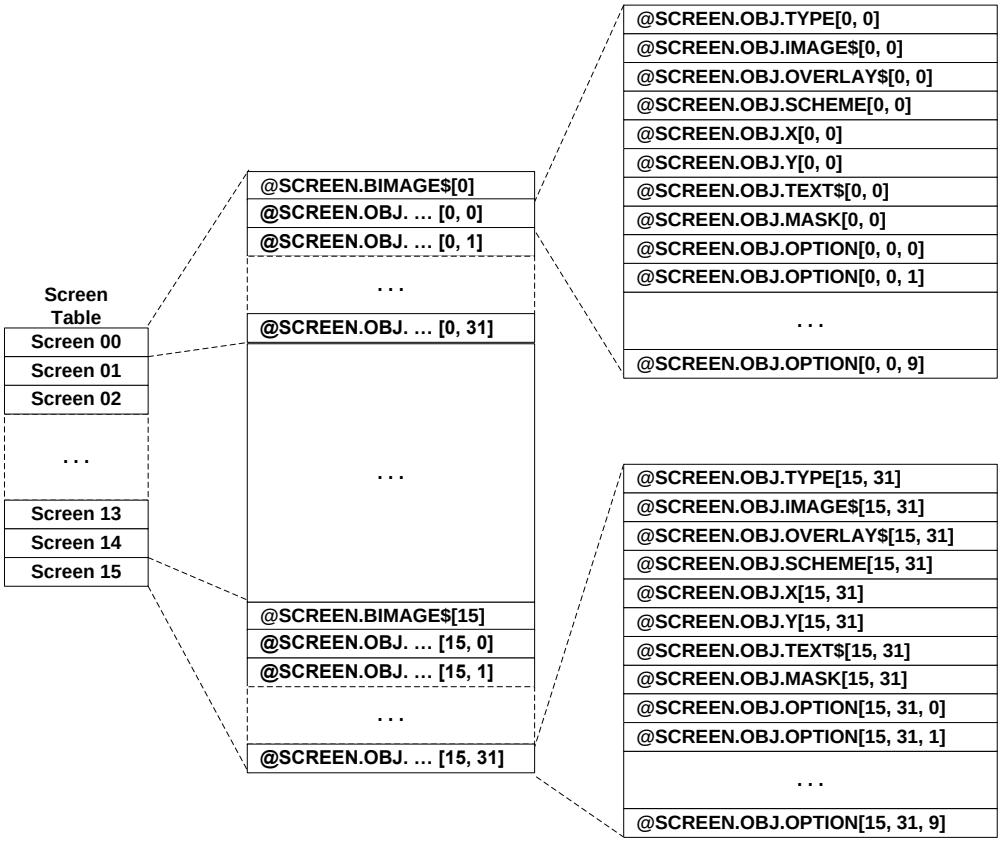
and feel for screen objects with the ability to easily change their appearance from one place. We'll examine schemes a little later on.

Controlling Screens and Objects

The Screen table elements are accessed using indexed system variables - the @SCREEN prefix is followed by one or more 'selectors' using the dot notation to select which entry's element is being accessed followed by the index to select the entry number in square brackets.

Accessing a Screen's object element requires a dual index to select the screen number then the object number. Finally, accessing a Screen Object's option element requires a triple index to select the screen number, object number and option number.

Here is a diagram showing the system variables and indices:



Touch Button Control

Let us try drawing a simple screen with no background image and a single button labeled 'Press'. Type in the following short program:

```
10 REM Button Demo
15 @ANSI.ENABLE=0 : REM Disable ANSI text
20 @SCREEN.OBJ.TYPE[0,0]=2 : REM Set screen 0 object 0 to Button type
25 @SCREEN.OBJ.SCHEME[0,0]=0 : REM Set button's scheme pair to 0,1
30 @SCREEN.OBJ.X[0,0]=116 : @SCREEN.OBJ.Y[0,0]=109 : REM Set button's location on screen
35 @SCREEN.OBJ.IMAGE$[0,0]="ButtonK4.bmp" : REM Set button's image
40 @SCREEN.OBJ.TEXT$[0,0]="Press" : REM Set button's text
45 SCREENS.CHANGETO 0 : REM Activate screen 0
999 GOTO 999
```

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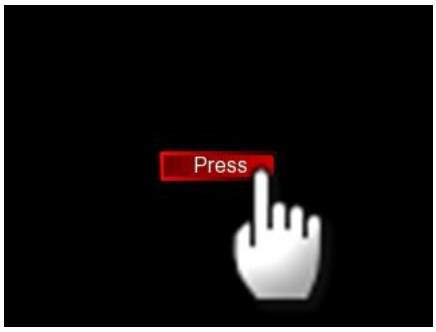
This program initializes the first screen object zero of the first screen table entry zero to position a button drawn using the built-in ButtonK4.bmp resource at the center of the screen. The gray button is labeled with the text 'Press' and is colorized using scheme table entry zero. The Screen Framework is then started by the navigation to this screen using the SCREENS.CHANGETO command.

Your display should look like the following – note how pressing the button changes its color shading automatically using the second entry of the scheme pair:



So how does your program 'know' when the user has pressed the button? There is a system variable that gets updated whenever a screen object changes state:

@SCREEN.OBJ.EVENT - This system variable reflects the last screen object event. There are currently three screen object events:

Value of @SCREEN.OBJ.EVENT	Indicates Screen Object Event
0	No event
1	Screen Object was touched
2	Screen Object value has changed
3	Screen Object was un-touched (released)

So let us change the program to watch this system variable and PRINT the event. To do this we'll use a new command – LIF, to control the program execution.

LIF is short for Long IF. If you remember the IF statement from *Controlling Program Execution* above, the command evaluates the following condition and IF it is True (non-zero) THEN it executes the command after the THEN otherwise it skips to the next line.

The LIF command works the same way except it executes all the commands on the line after the THEN when the condition evaluates to non-zero. This is useful when you want your program to do more than one command after testing a condition and avoid having to GOTO a new group of commands on another line to do so – it can make the program easier to write, follow and understand.

Add lines 50 – 65 below to the program and run it. These new lines test the value of the @SCREEN.OBJ.EVENT system variable and PRINT a message identifying the event. The event is then 'cleared' by setting it to zero and loops back to the top of the stack of LIF statements.

Try pressing and releasing the button and see what it printed:

```
10 REM Button Demo
15 @ANSI.ENABLE=0 : REM Disable ANSI text
20 @SCREEN.OBJ.TYPE[0,0]=2 : REM Set screen 0 object 0 type to Button
25 @SCREEN.OBJ.SCHEME[0,0]=0 : REM Set button's scheme pair to 0,1
30 @SCREEN.OBJ.X[0,0]=116 : @SCREEN.OBJ.Y[0,0]=109 : REM Set button's location on screen
35 @SCREEN.OBJ.IMAGE$[0,0]="ButtonK4.bmp" : REM Set button's image
40 @SCREEN.OBJ.TEXT$[0,0]="Press" : REM Set button's text
45 SCREENS.CHANGETO 0 : REM Activate screen 0
50 LIF @SCREEN.OBJ.EVENT = 1 THEN PRINT "Pressed" : @SCREEN.OBJ.EVENT = 0 : GOTO 50
55 LIF @SCREEN.OBJ.EVENT = 2 THEN PRINT "Value" : @SCREEN.OBJ.EVENT = 0 : GOTO 50
60 LIF @SCREEN.OBJ.EVENT = 3 THEN PRINT "Released" : @SCREEN.OBJ.EVENT = 0 : GOTO 50
65 GOTO 50
999 GOTO 999
```

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```
run
Pressed
Value
Released
Value
. . .
Pressed
Value
Released
Value
```

Note the sequence of screen object events; Pressed, Value, Released, Value. A button only has two values; 0 and 1, but other controls like a slider can have several values that change between being pressed then released.

Multiple Objects

So how does your program handle events for multiple objects on a screen? There is another system variable that gets updated at the same time as @SCREEN.OBJ.EVENT with the number of the object that caused the event:

@SCREEN.OBJ.# - This read-only system variable reflects the screen object number of the last screen object event.

The previous screen framework example for a single button polled the @SCREEN.OBJ.EVENT using the multiple LIF statements in a loop. However, the @SCREEN.OBJ.EVENT is event capable and, in an associated event handler, you can use the @SCREEN.OBJ.# system variable to identify what object the event is being generated from.

To simplify this processing we introduce a new ON command. The ON command provides the ability to change the program's execution using the value of an expression in a single statement instead of testing for each condition with multiple IF or LIF statements. It can make a program smaller and easier to read and understand.

The ON command is followed by the expression to evaluate, then the execution directive which can be either GOTO or GOSUB, and then a list of line numbers for each value of the expression. The destination line number is selected from the list by the value of the expression.

ON Expr, GOTO lineIfExpr=0, lineIfExpr=1, … , lineIfExpr=n

ON Expr, GOSUB lineIfExpr=0, lineIfExpr=1, … , lineIfExpr=n

If the expression evaluates to zero, the first line number in the list is used for the GOTO / GOSUB, an expression value of one selects the next line number, two the next and so on.

If the expression evaluates to a negative value, or to a value beyond the number of line numbers in the list, execution continues with the program statement following the ON command; this is the default case if there isn't a line number to jump to for an expression value. If the selected line number in the list is zero, execution continues with the program statement following the ON command; this allows certain expression values within the list of line numbers to be handled as defaults.

So let us add an event handler for the @SCREEN.OBJ.EVENT. We'll use the ON command to help process the event. We'll add a label object to the screen. The event handler will update the label object's .TEXT$ to display the button's last state; Pressed or Released. Here is the revised code:

```
10 REM Button Demo
15 @ANSI.ENABLE=0 : REM Disable ANSI text
20 @SCREEN.OBJ.TYPE[0,0]=2 : REM Set screen 0 object 0 to Button
25 @SCREEN.OBJ.SCHEME[0,0]=0 : REM Set button's scheme pair to 0,1
30 @SCREEN.OBJ.X[0,0]=116 : @SCREEN.OBJ.Y[0,0]=109 : REM Set button's location on screen
35 @SCREEN.OBJ.IMAGE$[0,0]="ButtonK4.bmp" : REM Set button's image
40 @SCREEN.OBJ.TEXT$[0,0]="Prog" : REM Set button's text
45 @SCREEN.OBJ.TYPE[0,1]=6 : REM set screen 0 object 1 to Label
50 @SCREEN.OBJ.SCHEME[0,1]=0 : REM set label's scheme pair to 0,1
55 @SCREEN.OBJ.X[0,1]=160 : @SCREEN.OBJ.Y[0,1]=151 : REM set label's location on screen
60 @SCREEN.OBJ.OPTION[0,1,0]=88 : REM override label width
65 ONEVENT @SCREEN.OBJ.EVENT,GOSUB 1000
70 SCREENS.CHANGETO 0 : REM activate screen 0
75 GOTO 75
1000 REM screen object event handler
```

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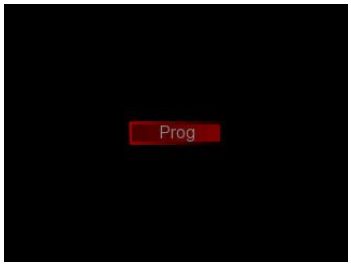
```
1005 IF @SCREEN.OBJ.#=0 THEN ON @SCREEN.OBJ.EVENT-1, GOTO 1015,0,1020
1010 RETURN
1015 @SCREEN.OBJ.TEXT$[0,1]="Pressed" : RETURN
1020 @SCREEN.OBJ.TEXT$[0,1]="Released" : RETURN
```

And now, when we run it and press the button the label above the button is updated to show the button's last state:



App started

Button pressed

Button released

Diving Into the Screen Framework

So how does this Screen Framework actually work? It uses messages and the multiple drawing surfaces system to perform its magic.

When the screen framework is started by the initial SCREENS.CHANGETO command, the screen is constructed using the following sequence of steps:

1) If there is a screen background image .BMP resource specified it is drawn onto the background surface, if not the background surface is filled with black.
2) Each screen object is sent a message to render their background information.
3) The background surface is then copied to the work surface.
4) Each screen object is sent a message to render their working information.
5) The work and display surfaces are then toggled so that what was the working surface is now the display surface and is being shown on the virtual screen.
6) Each screen object is sent a message to render any additional dynamic content on the displayed surface.

After the screen is constructed, a construction event is signaled via the @SCREEN.EVENT system variable, with the @SCREEN.# variable identifying what screen number the event is being generated from. This allows the Basic program to initialize any variables, start timers or perform other functions specific to or required by the activating screen.

If a new screen is navigated to by a .CHANGETO or .PUSH or .POP command while a current screen is being displayed, a destruction event is signaled via the @SCREEN.EVENT variable and then the new screen is constructed. This allows the Basic program to stop timers or disable other functions that were in use by the previous screen.

When the user touches the screen a message containing the touch state; press, move or release, along with the screen coordinates is sent to each object on the screen. Each object determines whether it is affected by the touch event, possibly updating its state and updating its appearance on the screen. If the object determines is has been touched or its .VALUE has changed an event is signaled via the @SCREEN.OBJ.EVENT system variable, with the @SCREEN.OBJ.# variable identifying what screen object number the event is being generated from.

The Basic program can DRAW on the display surface after the screen constructed event has occurred. Any drawing done on the display surface between the SCREEN navigation command and the screen constructed event would appear to be drawn on the work surface after step 3 above occurs. Double buffer or ping-pong drawing should not be performed as it will interfere with the Screen Framework's operation.

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Screen object's .VALUEs can be changed by the program to cause the object to change its appearance on the screen. These changes should be made after the object's containing screen has been constructed as determined by the construction event. Changes before the occurrence of the screen construction event may be overwritten or discarded until the screen (and its objects) have been constructed.

Using the screen framework and controls can simplify a Basic graphics application as the screens and objects manage the drawing surfaces and render themselves in response to system variable changes and user touch interaction.

Rules for the Screen Framework

1. The Screen Framework is comprised of multiple system variable tables that specify what objects (controls) are located where on each screen and how they are displayed.
2. The Screen Framework is started by the first SCREENS.CHANGETO or SCREENS.PUSHTO command.
3. Screens are not stored fully rendered but are constructed (drawn) when navigated to.
4. Screens and screen objects signal changes by using events.
5. Screens can be DRAWn on after they are constructed but not by using the double-buffering technique.

to be continued…

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Acs Basic Graphics System Variables

ACS Basic also has built-in display system variables. System variables are denoted by a '**@**' character as the first character of the variable name. The system variable names are 'tokenized' when entered to save program memory and speed program execution: for example the system variable **@BACKLIGHT** would be tokenized to two bytes instead of seven bytes.

System variables **may not** be assigned a value by appearing in an **FOR, DIM, INPUT, READ, FINPUT #N** or **FREAD #N** statement. Some system variables are read-only and may not appear on the left hand side of a **LET** assignment statement.

Some system variables have ***Events*** associated with them and may be referenced in **ONEVENT, SIGNAL** and **WAIT** statements. See the description for the individual system variables and the ***Events*** section below for more information.

@ANSI.

These system variables are used to how and when Basic PRINT statements also affect the display.

@ANSI.ENABLE

This system variable enables or disables whether PRINT statements are also sent to the display as ANSI text. The default is enabled (1). See the PRINT statement below for additional information.

@ANSI.CURSOR

This system variable enables or disables whether a blinking cursor is displayed on the display when @ANSI.ENABLE=1. The default is enabled (1).

@ANSI.SCROLL

This system variable enables or disables whether a line feed on the last line of the display causes the screen to scroll up when @ANSI.ENABLE=1. The default is enabled (1).

@ANSI.WRAP

This system variable enables or disables whether PRINTed text on the display wraps to the next line when it reaches the end of a line when @ANSI.ENABLE=1. The default is enabled (1).

@ANSI.ROW

This system variable gets or sets the current row where PRINTed text will be placed.

@ANSI.COL

This system variable gets or sets the current column where PRINTed text will be placed.

@BACKLIGHT

This system variable controls the display backlight. Setting it to zero dims the backlight to the configured off setting, setting it to one brightens the backlight to the configured on setting and setting it to 2 brightens the backlight and starts the configured automatic backlight dim timer.

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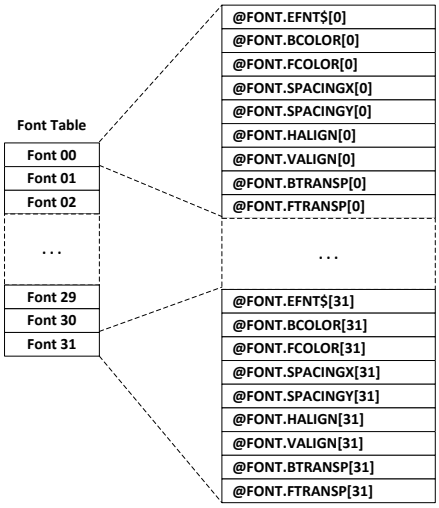
@FONT.

These system variables are used to access the individual elements of the Font table. They require an index that ranges from 0 to 31 to refer to the 32 Font table entries.



@FONT.EFNT$[n]

This system variable sets or gets the embedded font resource name in the resource table for this Font table entry.

@FONT.BCOLOR[n]

This system variable sets or gets the background color for Font table entry n:

@FONT.BCOLOR[n] = RGB(R, G, B)

Field	Description
`n`	Font table entry #
`RGB(R, G, B)`	Background color as RGB565

@FONT.FCOLOR[n]

This system variable sets the foreground color for Font table entry n:

@FONT.FCOLOR[n] = RGB(R, G, B)

Field	Description
`n`	Font table entry #
`RGB(R, G, B)`	Background color as RGB565

@FONT.SPACINGX[n]

This system variable sets the horizontal spacing for Font table entry n:

@FONT.SPACINGX[n] = x

Field	Description
`n`	Font table entry #
`x`	0 = fixed width of the font 1→14 = pixels between characters 15 = bounding box character width

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@FONT.SPACINGY[n]

This system variable sets the vertical spacing for Font table entry n:

@FONT.SPACINGY[n] = y

Field	Description
n	Font table entry #
y	0 = fixed width of the font 1→14 = pixels between characters 15 = bounding box character width

@FONT.HALIGN[n]

This system variable sets the horizontal alignment (justification) for Font table entry n:

@FONT.HALIGN[n] = h

Field	Description
n	Font table entry #
h	0 = Left Justify 1 = Center Justify 2 = Right Justify

@FONT.VALIGN[n]

This system variable sets the vertical alignment (justification) for Font table entry n:

@FONT.VALIGN[n] = v

Field	Description
n	Font table entry #
v	0 = Top Justify 1 = Center Justify 2 = Bottom Justify

This short program shows the effect of the @FONT.HALIGN and @FONT.VALIGN system variables:

```
5 REM Test @FONT.HALIGN and @FONT.VALIGN
10 @ANSI.CURSOR=0:@ANSI.ENABLE=0:@BACKLIGHT=1
20 REM Draw grid
30 DRAW.LINE 10,0,10,239,RGB(255,0,0)
40 DRAW.LINE 160,0,160,239,RGB(255,0,0)
50 DRAW.LINE 309,0,309,239,RGB(255,0,0)
60 DRAW.LINE 0,10,319,10,RGB(255,0,0)
70 DRAW.LINE 0,120,319,120,RGB(255,0,0)
80 DRAW.LINE 0,229,319,229,RGB(255,0,0)
90 REM Draw aligned text
100 @FONT.HALIGN[0]=0:@FONT.VALIGN[0]=0:DRAW.TEXT 0,10,10,"LEFT,BOT"
110 @FONT.HALIGN[0]=1:@FONT.VALIGN[0]=0:DRAW.TEXT 0,160,10,"MID,BOT"
120 @FONT.HALIGN[0]=2:@FONT.VALIGN[0]=0:DRAW.TEXT 0,309,10,"RIGHT,BOT"
130 @FONT.HALIGN[0]=0:@FONT.VALIGN[0]=1:DRAW.TEXT 0,10,120,"LEFT,MID"
140 @FONT.HALIGN[0]=1:@FONT.VALIGN[0]=1:DRAW.TEXT 0,160,120,"MID,MID"
150 @FONT.HALIGN[0]=2:@FONT.VALIGN[0]=1:DRAW.TEXT 0,309,120,"RIGHT,MID"
160 @FONT.HALIGN[0]=0:@FONT.VALIGN[0]=2:DRAW.TEXT 0,10,229,"LEFT,TOP"
170 @FONT.HALIGN[0]=1:@FONT.VALIGN[0]=2:DRAW.TEXT 0,160,229,"MID,TOP"
180 @FONT.HALIGN[0]=2:@FONT.VALIGN[0]=2:DRAW.TEXT 0,309,229,"RIGHT,TOP"
190 GOTO 190
```

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@FONT.BTRANSP[n]

This system variable sets the background transparency for Font table entry n:

@FONT.BTRANSP[n] = b

Field	Description
n	Font table entry #
b	0 = Solid 1 = Transparent

@FONT.FTRANSP[n]

This system variable sets the foreground transparency for Font table entry n:

@FONT.FTRANSP[n] = b

Field	Description
n	Font table entry #
b	0 = Solid 1 = Transparent

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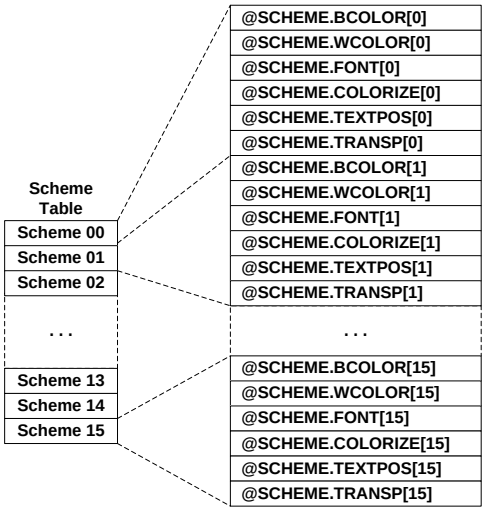
@SCHEME.

These system variables are used to access the individual elements of the Scheme table. They require an index that ranges from 0 to 15 to refer to the 16 scheme table entries. Schemes are used in pairs with the lower numbered scheme entry used for rendering 'un-pressed' or inactive screen icons and the higher number entry of the pair used for rendering 'pressed' or active screen icons.



@SCHEME.FONT[n]

This system variable gets or sets the font table entry number to be used for Scheme table entry n:

@SCHEME.FONT[n] = f

Field	Description
`n`	Scheme table entry #
`f`	0-31 = Fonts table entry #

@SCHEME.BCOLOR[n]

This system variable gets or sets the black replace color to be used for Scheme table entry:

@SCHEME.BCOLOR[n] = RGB(R, G, B)

Field	Description
`n`	Scheme table entry #
`RGB(R, G, B)`	Black replacement color as RGB565

@SCHEME.WCOLOR[n]

This system variable gets or sets the white replace color to be used for Scheme table entry n:

@SCHEME.WCOLOR[n] = RGB(R, G, B)

Field	Description
`n`	Scheme table entry #
`RGB(R, G, B)`	White replacement color as RGB565

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@SCHEME.COLORIZE[n]

This system variable gets or sets the colorization mode to be used for Scheme table entry n:

@SCHEME.COLORIZE[n] = c

Field	Description
n	Scheme table entry #
c	0 = no change 1 = grayscale 2 = shade

@SCHEME.TEXTPOS[n]

This system variable gets or sets the text position to be used for this Scheme table entry n:

@SCHEME.TEXTPOS[n] = p

Field	Description
n	Scheme table entry #
p	0 = no text 1 = centered 2-511 = X, Y position:

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@SCHEME.TRANSP[n]

This system variable gets or sets the transparency mode to be used for Scheme table entry n:

@SCHEME.TRANSP[n] = m

Field	Description
n	Schemes table entry #
m	(see following table)

m	Operation	Transparency Color Value	Description
0	Magic Value	Magic index	For indexed .BMP images only, the last index value is the magic color.
1	None	Not used	Surface pixel = image pixel.
2	Darken	Scheme white replace color to be used as a multiplier	Surface pixel = surface pixel * RGB565 color.
3	Source Color Filter	Not used	Surface pixel = surface pixel * image pixel (5:6:5 channel by channel multiply).
4	Source Alpha Mask	Scheme white replace color to be used as a 'white' replacement	Surface pixel = (surface pixel * RG565 color) + (1 – image pixel) * surface pixel (treats image as an alpha mask, white solid, black transparent, intermediate blended).
5	Fill	Scheme white replace fill color	Surface pixel = RGB565 color
6	Transparency Blend	Scheme white replace color to use as an Alpha multiplier	Surface pixel = (RGB565 color * image pixel) + (1 – RGB565 color) * surface pixel (blends image into surface by ratio determined by RGB565 color).
7	Shadow	Scheme white replace color to use as an Alpha multiplier	Surface pixel = (RGB565 color * image pixel * surface pixel) + (1 – image pixel) * surface pixel (image is mask to apply multiplication of RGB565 color).

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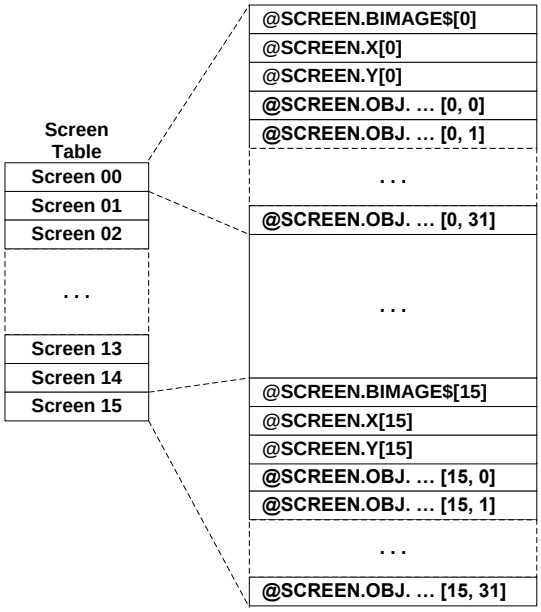
@SCREEN.

These system variables are used to access the individual elements of the Screen table. They require an index that ranges from 0 to 15 to refer to the 16 screen table entries.



@SCREEN.BIMAGE$[n]

This system variable is used to set the optional background image for the Screen table entry n to an image resource:

@SCREEN.BIMAGE$[n] = ”MyImageResource.bmp”

@SCREEN.X[n]

This system variable is used to set the lower left horizontal position of the displayed screen.

@SCREEN.Y[n]

This system variable is used to set the lower left vertical position of the displayed screen.

@SCREEN.#

This read-only system variable reflects the screen number of the last screen event.

@SCREEN.EVENT

This system variable reflects the last screen event. There are two screen events:

@SCREEN.EVENT	Event
1	Screen[@SCREEN.#] hidden by: SCREENS.CHANGETO or SCREENS.PUSHTO
2	Screen[@SCREEN.#] shown by: SCREENS.CHANGETO or SCREENS.POP

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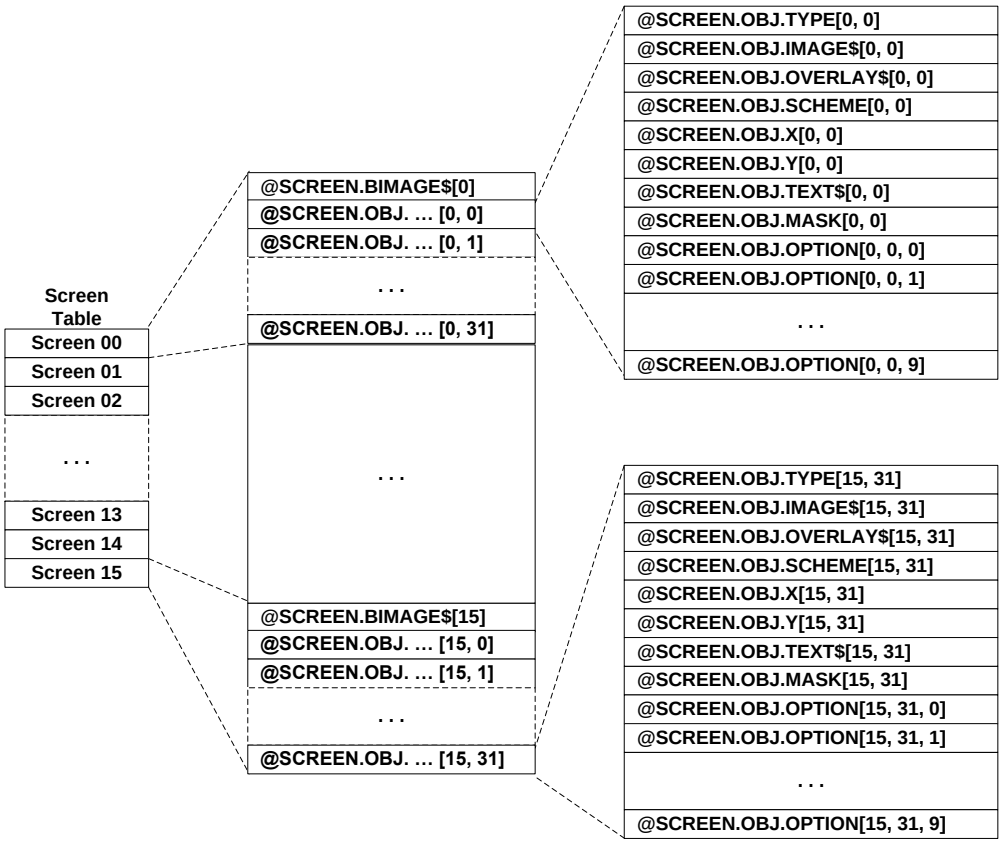
@SCREEN.OBJ.

These system variables are used to access the individual attributes of the screen objects associated with each Screen table entry.

They require a double index – the first index selects the Screen table entry, and the second index selects the screen object entry for the selected screen entry. The first index ranges from 0 to 15 to refer to the 16 Screen table entries, and the second index ranges from 0 to 15 to refer to the 16 screen object table entries for each screen.

Screen object table entries have to be entered starting at zero and cannot have any gaps – unused entries will not be skipped over and processing stops at the first unused entry.



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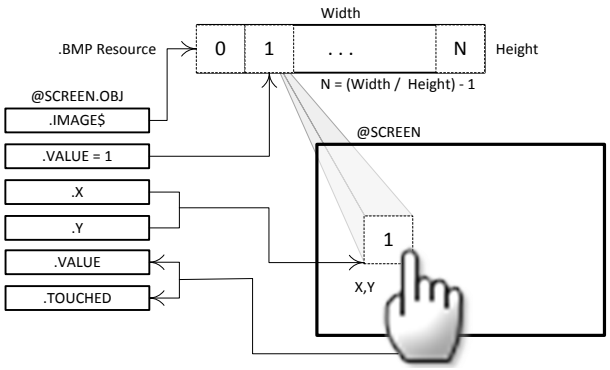
@SCREEN.OBJ.TYPE[screen, object]

This system variable sets the screen object type for Screens table entry screen, object entry:

@SCREEN.OBJ.TYPE	Object Type
0	None
1	Icon
2	Button
3	Toggle Button
4	Back Button
5	Slider
6	Label
7	Touch Keypad
8	Radial Gauge
9	Linear Gauge
10	Listbox
11	Spinner Knob
12	Text Box

Icon Screen Object

The Icon screen object displays a portion of a bitmap resource where the displayed portion of the bitmap is controlled by the screen object's .VALUE. The displayed portion of the bitmap may be a square based upon the image width divided by the image height or a portion selected from the bitmap width divided by an .OPTION value. The auto-advance of the image portion when touched can be disabled by an .OPTION property.



A checkbox control can be implemented by using a .IMAGE$ bitmap resource containing the checkbox with and without the checkmark. Notice the magenta background which will become transparent when the control is rendered:

Here's a short program that puts this checkbox on the screen. When it is run the checkbox can be toggled between unchecked and checked by touching it:

```
5 REM Icon control used as Checkbox
10 @ANSI.ENABLE=0
20 @SCREEN.OBJ.TYPE[0,0]=1
30 @SCREEN.OBJ.IMAGE$[0,0]="Icon_CheckBox_Indexed_48x24.bmp"
40 @SCREEN.OBJ.X[0,0]=160:@SCREEN.OBJ.Y[0,0]=120
100 SCREENS.CHANGETO 0
999 GOTO 999
```

An animation capability can be achieved by advancing the object's .VALUE property on a timer event causing the icon screen object to advance through the contained images.

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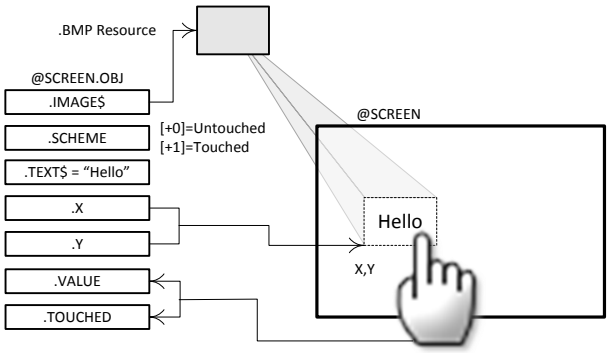
Button Screen Object

The Button screen object displays a bitmap with a .TEXT$ label that acts like an on-screen button. The button can auto-colorize for press/release feedback using the object's .SCHEME and can provide .EVENT notifications.



To support the pop-up keypad, the Color LCD has four built-in bitmap resources that it uses as buttons. These buttons are gray in color and are colorized by the screen object's .SCHEME when rendered:

ButtonK.bmp
22 x 22

ButtonK2.bmp
44 x 22

ButtonK4.bmp
88 x 22

ButtonM.bmp
48 x 32

Here's a simple program that displays one of those buttons – when it is run the button is colorized and it highlights when it is pressed on the screen:

```
10 REM Button Demo
15 @ANSI.ENABLE=0 : REM Disable ANSI text
20 @SCREEN.OBJ.TYPE[0,0]=2 : REM Set screen 0 object 0 to Button
25 @SCREEN.OBJ.SCHEME[0,0]=0 : REM Set button's scheme pair to 0,1
30 @SCREEN.OBJ.X[0,0]=116 : @SCREEN.OBJ.Y[0,0]=109 : REM Set button's location on screen
35 @SCREEN.OBJ.IMAGE$[0,0]="ButtonK4.bmp" : REM Set button's image
40 @SCREEN.OBJ.TEXT$[0,0]="Press" : REM Set button's text
45 SCREENS.CHANGETO 0 : REM activate screen 0
999 GOTO 999
```

Toggle Button Screen Object

The Toggle Button screen object displays a bitmap with the object's .TEXT$ label that acts like an on-screen latching button – each press/release toggles the button state. The button can auto-colorize for press/release feedback using the object's .SCHEME and provide .EVENT notifications. The same program can demonstrate the toggle functionality by simply changing the object type:

```
10 REM Toggle Button Demo
15 @ANSI.ENABLE=0 : REM Disable ANSI text
20 @SCREEN.OBJ.TYPE[0,0]=3 : REM Set screen 0 object 0 to Toggle Button
25 @SCREEN.OBJ.SCHEME[0,0]=0 : REM Set button's scheme pair to 0,1
30 @SCREEN.OBJ.X[0,0]=116 : @SCREEN.OBJ.Y[0,0]=109 : REM Set button's location on screen
35 @SCREEN.OBJ.IMAGE$[0,0]="ButtonK4.bmp" : REM Set button's image
40 @SCREEN.OBJ.TEXT$[0,0]="Press" : REM Set button's text
45 SCREENS.CHANGETO 0 : REM activate screen 0
999 GOTO 999
```

Back Button Screen Object

The Back Button screen object displays a bitmap with the object's .TEXT$ label that will pop the screen stack when pressed. The button can auto-colorize for press/release feedback using the object's .SCHEME and provide .EVENT notifications.

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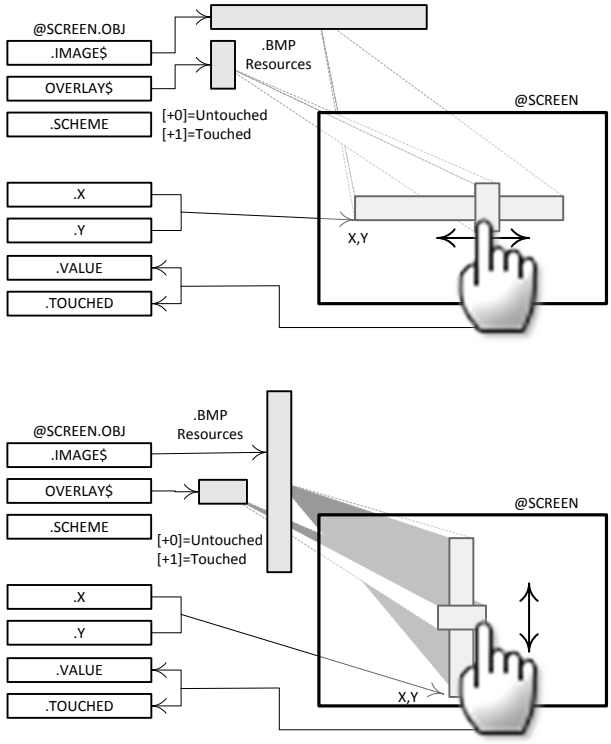
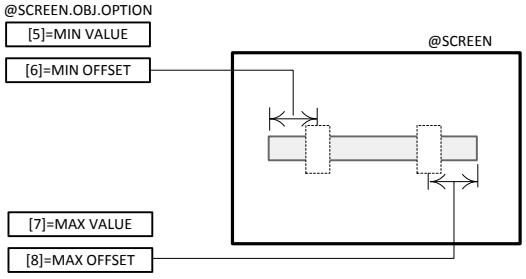
Slider Screen Object

The Slider screen object displays a horizontal or vertical slider. The slider uses two bitmap resources configured with the .IMAGE$ and .OVERLAY$. The IMAGE$ bitmap resource supplies the slider base and the .OVERLAY$ bitmap resource supplies the slider button.

The slider orientation is controlled by the aspect ratio of the .IMAGE$ resource – bitmaps that are wider than they are tall operate horizontally and bitmaps that are taller than they are wide operate vertically.



The slider screen object can be configured for min/max values and corresponding button center to base bitmap pixel offsets via the .OPTION properties.



If an .OPTION offset property is zero the corresponding offset is equal to the width (height) of the button bitmap.

If both of the .OPTION min and max value properties are zero the slider object's .VALUE ranges from 0 ↔ 32767.

Here are two bitmaps for a horizontal slider – the base .IMAGE$ and the button .OVERLAY$ Notice the green background that will become transparent when the control is rendered:

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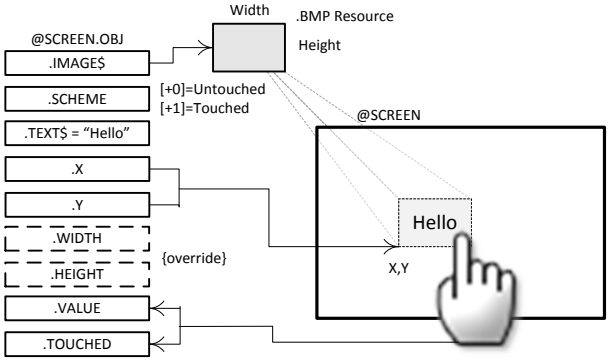
And here's a short program to initialize and display the slider:

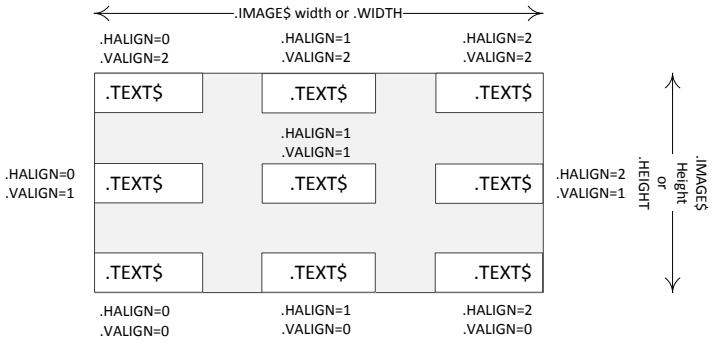
```
5 REM slider demo
10 @ANSI.ENABLE=0
15 @SCREEN.OBJ.TYPE[0,0]=5 : REM screen 0 object 0 slider
20 @SCREEN.OBJ.IMAGE$[0,0]="Slider_Red_H_WDivisions234x31.bmp"
25 @SCREEN.OBJ.OVERLAY$[0,0]="SliderButton_Red_H_19x26.bmp"
30 @SCHEME.COLORIZE[0]=0 : @SCHEME.TRANSP[0]=0 : @SCHEME.COLORIZE[1]=0 : @SCHEME.TRANSP[1]=0
35 @SCREEN.OBJ.SCHEME[0,0]=0
40 @SCREEN.OBJ.X[0,0]=(320-234)/2 : @SCREEN.OBJ.Y[0,0]=(240-31)/2
45 SCREENS.CHANGETO 0
999 GOTO 999
```

Label Screen Object

The Label screen object displays the object's .TEXT$ justified within the control's .IMAGE$ bitmap resource. The width and height of the displayed text area is controlled by the .IMAGE$ width and height or it can be overridden via the .WIDTH and .HEIGHT values. If no .IMAGE$ bitmap resource is specified a box of the configured TPAD_Scheme's off color is drawn if the object's .SCHEME's .FONT's background is not transparent.



The position of the .TEXT$ within the label boundary is controlled by the .SCHEME font justification – the object's scheme FONT.HALIGN and FONT.VALIGN properties:



Touch Keypad Screen Object

The Touch Keypad screen object provides the ability for the screen to pop-up and display several different on-screen keypads and receive the pressed characters as input.

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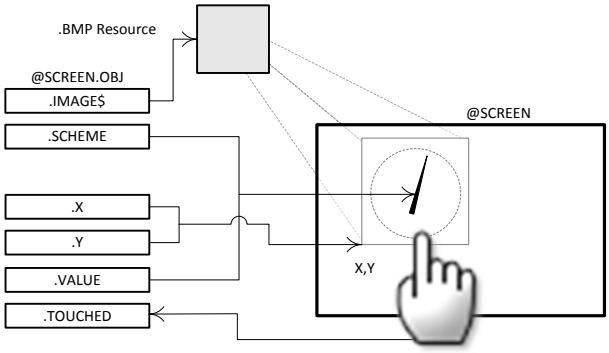
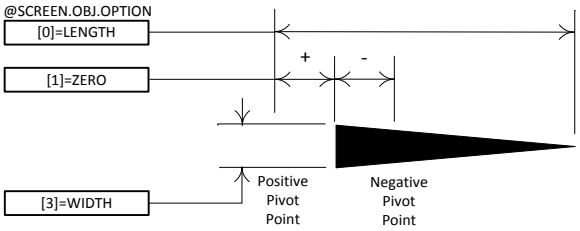
Radial Gauge Screen Object

The Radial Gauge screen object displays the .IMAGE$ bitmap resource with an overlaid graphical needle that can be justified to the bitmap and configured for angle and value range using .OPTION properties. The object's .VALUE then sets the needle angle.

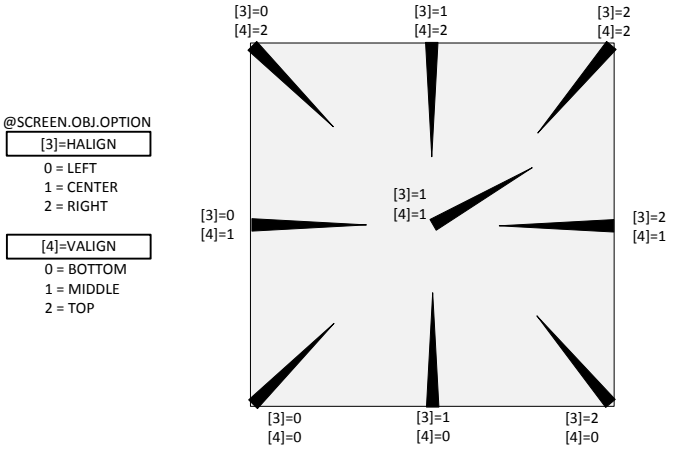


The first three .OPTION properties set the gauge needle length, pivot point offset and width in pixels. A positive pivot point offset allows the needle to rotate about a point before its base. A negative pivot point offset allows the needle to rotate about a point along its length.

Shorter, skinnier needles draw faster.



The next two .OPTION properties align the needle's pivot point to the .IMAGE$ bitmap resource.



The last four .OPTION properties configure the needle's minimum and maximum angles and the corresponding minimum and maximum values. Both the angles and values can be negative. Angles advance in value counter-clockwise rotation with zero to the right as shown in the following diagram.

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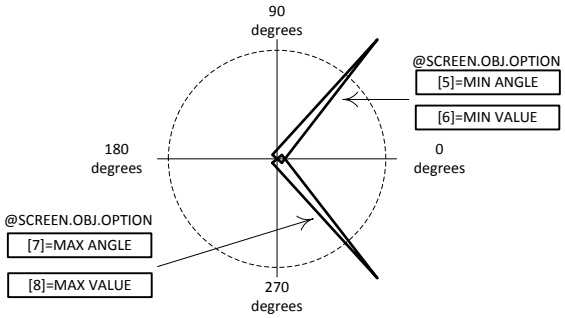
The minimum angle is the angle the needle will be drawn at when the object's .VALUE is at the specified minimum value.

The maximum angle is the angle the needle will be drawn at when the object's .VALUE is at the specified maximum value.



Here is a bitmap for a tachometer radial gauge:

And here's a short program that initializes a screen object as a radial gauge using this bitmap, then runs the tach from 0 to 10,000 and back down in a loop:

```
5 REM Tachometer
10 @ANSI.ENABLE=0:@BACKLIGHT=1
15 @SCHEME.WCOLOR[0]=RGB(255,0,0):REM needle color
20 @SCREEN.OBJ.TYPE[0,0]=8:REM radial gauge
25 @SCREEN.OBJ.OPTION[0,0,0]=95:REM needle length
30 @SCREEN.OBJ.OPTION[0,0,1]=18:REM needle zero
35 @SCREEN.OBJ.OPTION[0,0,2]=6:REM needle width
40 @SCREEN.OBJ.OPTION[0,0,3]=1:REM needle halign
45 @SCREEN.OBJ.OPTION[0,0,4]=1:REM needle valign
50 @SCREEN.OBJ.OPTION[0,0,5]=0:REM min value
55 @SCREEN.OBJ.OPTION[0,0,6]=225:REM min angle
60 @SCREEN.OBJ.OPTION[0,0,7]=10000:REM max value
65 @SCREEN.OBJ.OPTION[0,0,8]=-25:REM max angle
70 @SCREEN.OBJ.IMAGE$[0,0]="Gauge-Tach-Black-3QTR-196x196.bmp"
75 SCREENS.CHANGETO 0
80 WAIT @SCREEN.EVENT
95 FOR n=0 TO 10000 STEP 20:@SCREEN.OBJ.VALUE[0,0]=n:NEXT n
100 FOR n=10000 TO 0 STEP -20:@SCREEN.OBJ.VALUE[0,0]=n:NEXT n
105 GOTO 95
```

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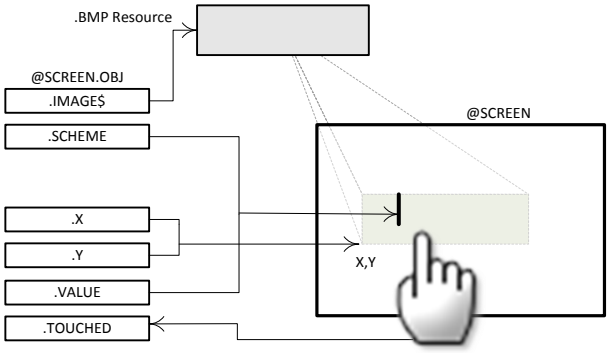
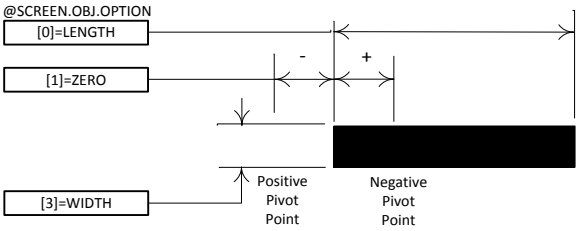
Linear Gauge Object

The Linear Gauge screen object display the .IMAGE$ bitmap resource with overlaid graphical needle that can be justified to the bitmap and configured for offset and value range using the .OPTION properties. The object's .VALUE then sets the needle position.

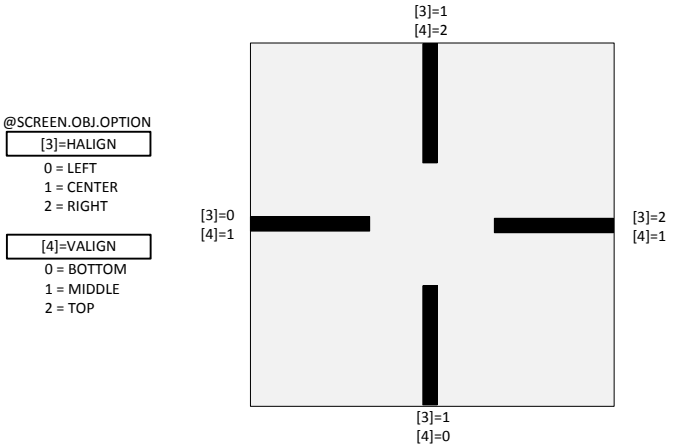


The first three .OPTION properties set the gauge needle length, zero offset and width in pixels. A positive zero offset allows the needle to move along a line parallel to and inside its base. A negative offset allows the needle to move along a line parallel to and outside of its base.

Shorter, skinnier needles draw faster.



The next two .OPTION properties align the needle to the .IMAGE$ bitmap resource.



The last four .OPTION properties configure the needle's minimum and maximum offsets and the corresponding minimum and maximum values. Both the offsets and values can be negative.

The minimum offset is the offset from the .IMAGE$ edge the needle will be drawn at when the object's .VALUE is at the specified minimum value.

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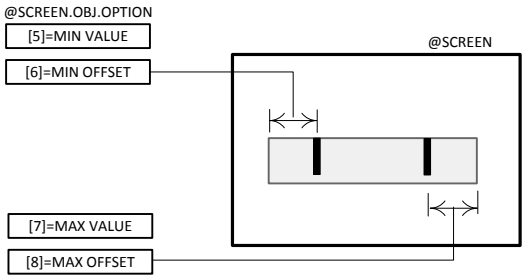
The maximum offset is the offset from the .IMAGE$ edge the needle will be drawn at when the object's .VALUE is at the specified maximum value.



Listbox Screen Object

The Listbox screen object displays the .IMAGE$ bitmap resource with overlaid up/down buttons on the right hand side and the object's DATA displayed as text strings using the object's .SCHEME font.

If no .IMAGE$ bitmap resource is specified a box of the configured TPAD_Scheme's off color is drawn if the object's .SCHEME's .FONT's background is not transparent. A bounding box of the .WIDTH and .HEIGHT is then drawn in the configured TPAD_Scheme's on color.

The number of displayed items and the topmost item in the list may be controlled by .OPTION properties.

An item may be selected or deselected by touching. The object's .VALUE reflects the selected item number with minus one (-1) indicating no item is selected.

Here's a short program that displays a listbox control with some character strings that displays the selected item at the top of the screen in a label control:

```
10 REM listbox
15 @ANSI.ENABLE = 0 : @BACKLIGHT = 1
20 INCLUDE "constants.bas"
25 CONST LBox = 0 : @SCREEN.OBJ.TYPE[0,LBox] = Listbox
30 REM @SCREEN.OBJ.IMAGE$[0,0] = "PopUp_160x120.bmp"
35 @FONT.HALIGN[8] = 0 : @FONT.HALIGN[9] = 0 : @SCREEN.OBJ.SCHEME[0,0] = 8
40 @FONT.FCOLOR[9] = RGB(255,255,0)
45 @SCREEN.OBJ.X[0,LBox]=ScreenWidth / 2 - 160 / 2 : @SCREEN.OBJ.Y[0,LBox]=ScreenHeight / 2 - 120 / 2
50 @SCREEN.OBJ.WIDTH[0,LBox] = 160 : @SCREEN.OBJ.HEIGHT[0,LBox] = 90
55 CONST Readout=1 : @SCREEN.OBJ.TYPE[0,Readout] = Label
60 @SCREEN.OBJ.X[0,Readout] = 160-100 : @SCREEN.OBJ.Y[0,Readout] = 220
65 @SCREEN.OBJ.WIDTH[0,Readout] = 200 : @SCREEN.OBJ.HEIGHT[0,Readout] = 20
70 @SCREEN.OBJ.MASK[0,Readout] = None
75 DIM items$[9]
80 items$[0] = "this is line one" : items$[1] = "this is line two" : items$[2] = "this is line three"
85 items$[3] = "this is line four" : items$[4] = "this is line five" : items$[5] = "this is line six"
90 items$[6] = "this is line seven" : items$[7] = "this is line eight" : items$[8] = "this is line nine"
95 SCREEN.OBJ.DATA 0,LBox,0,items$ : @SCREEN.OBJ.OPTION[0,LBox,NumberOfItems] = UBOUND(items$)
100 ONEVENT @SCREEN.OBJ.EVENT,GOSUB `Handler
105 SCREENS.CHANGETO 0
110 WAIT @SCREEN.EVENT
115 @SCREEN.OBJ.VALUE[0,LBox] = -1 : REM nothing selected
999 GOTO 999
1000 `Handler : REM screen object event handler
1005 LIF @SCREEN.OBJ.# = LBox THEN ON @SCREEN.OBJ.EVENT-1,GOTO 0,`Selector,0
1010 RETURN
1015 `Selector : IF @SCREEN.OBJ.VALUE[0,LBox] >= 0 THEN
1020 @SCREEN.OBJ.TEXT$[0,Readout] = items$[@SCREEN.OBJ.VALUE[0,LBox]] + " selected"
1025 ELSE
1030 @SCREEN.OBJ.TEXT$[0,Readout] = "nothing selected"
1035 ENDIF
1040 RETURN
```

And here is the resulting display:

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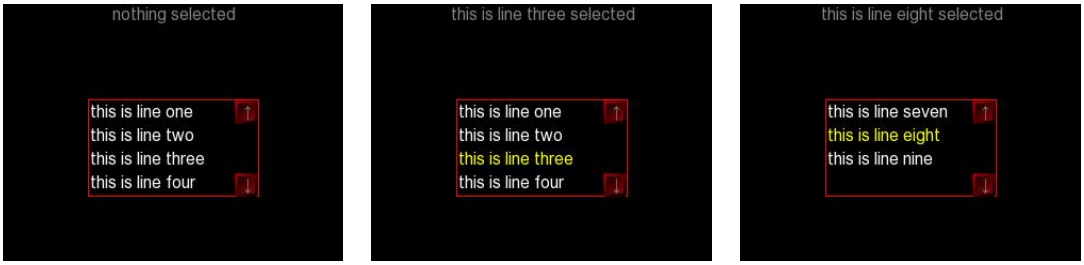
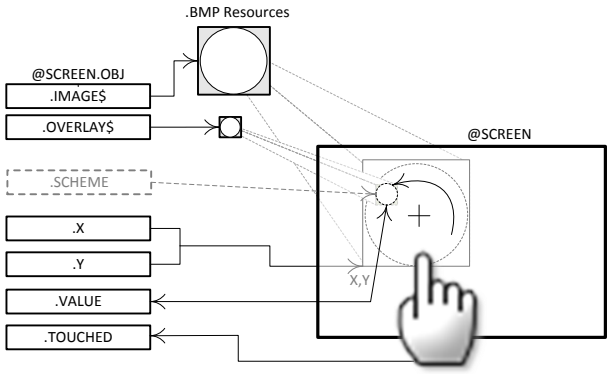

nothing selected
this is line one
this is line two
this is line three
this is line four
this is line three selected
this is line one
this is line two
this is line three
this is line four
this is line eight selected
this is line seven
this is line eight
this is line nine

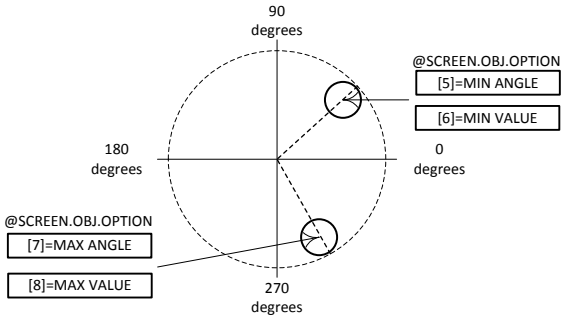
Spinner Knob Object

The Spinner Knob screen object displays a rotary knob with a smaller spinner handle or radial indicator line. The slider uses two bitmap resources configured with the .IMAGE$ and .OVERLAY$. The IMAGE$ bitmap resource supplies the base rotary know and the .OVERLAY$ bitmap resource supplies the spinner handle. The object's .VALUE gets (or sets) the position of the .OVERLAY$ bitmap resource in an arc relative to the .IMAGE$ bitmap resource's center.

If an .OVERLAY$ image is not provided, a radial indicator line is drawn instead. The color of the radial line is controlled by the screen object's .SCHEME.WCOLOR[0], and the indicator length, zero and width are controlled by three screen object .OPTION values.



The spinner handle / indicator position and value relationship is controlled by four screen object .OPTION values.



Here are two bitmaps for a spinner knob screen object – the base .IMAGE$ and the spin handle .OVERLAY$. Notice the magenta background that will become transparent when the control is rendered:

Knob_150x150.bmp

Spinner_33x33.bmp

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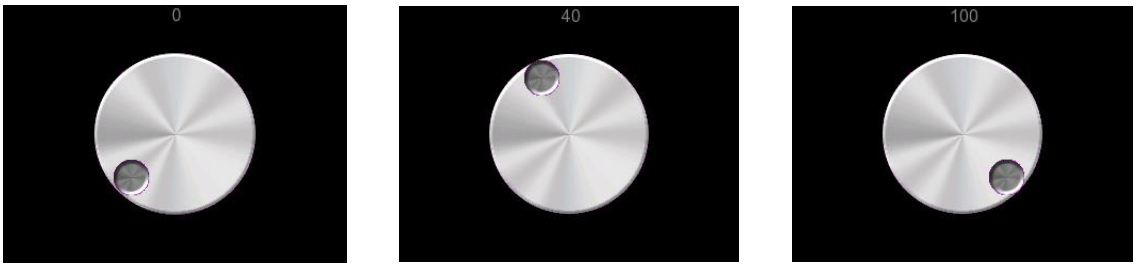
And here is a sample program that displays the knob at the center of the screen along with a label at the top of the screen showing the .VALUE as the knob is rotated by touching and turning:

```
10  REM spinner knob
15  INCLUDE "constants.bas"
20  @ANSI.ENABLE = False : @BACKLIGHT = True
25  CONST Knob=0 : @SCREEN.OBJ.TYPE[0,Knob] = SpinnerKnob
30  @SCREEN.OBJ.IMAGE$[0,Knob]="Knob_150x150.bmp" : @SCREEN.OBJ.OVERLAY$[0,Knob]="Spinner_33x33.bmp"
35  @SCREEN.OBJ.X[0,Knob]=ScreenWidth / 2 - 150 / 2 : @SCREEN.OBJ.Y[0,Knob]=ScreenHeight / 2 - 150 / 2
40  @SCREEN.OBJ.OPTION[0,Knob,MinValue] = 0 : @SCREEN.OBJ.OPTION[0,Knob,MinAngle] = 225
45  @SCREEN.OBJ.OPTION[0,Knob,MaxValue] = 100 : @SCREEN.OBJ.OPTION[0,Knob,MaxAngle] = -45
50  CONST Readout=1 : @SCREEN.OBJ.TYPE[0,Readout] = Label
52  @SCREEN.OBJ.X[0,Readout] = 160-25 : @SCREEN.OBJ.Y[0,Readout] = 220
55  @SCREEN.OBJ.WIDTH[0,Readout] = 50 : @SCREEN.OBJ.HEIGHT[0,Readout] = 20
60  @SCREEN.OBJ.MASK[0,Knob] = ValueChanged : @SCREEN.OBJ.MASK[0,Readout] = None
65  ONEVENT @SCREEN.OBJ.EVENT, GOSUB 10000
100  SCREENS.CHANGETO 0
110  WAIT @SCREEN.EVENT
115  @SCREEN.OBJ.VALUE[0,Knob] = 0
120  GOTO 120
10000  REM screen object event handler
10005  @SCREEN.OBJ.TEXT$[0,Readout] = STR$(@SCREEN.OBJ.VALUE[0,Knob])
10010  RETURN
```

In order to make the program easier to follow it includes a file “constants.bas” that defines several constant variables:

```
CONST False=0,True=1
CONST ScreenWidth=320,ScreenHeight=240
REM Screen Object Types
CONST None=0,Icon=1,Button=2,ToggleButton=3,BackButton=4,Slider=5,Label=6,TouchKeypad=7,RadialGauge=8
CONST LinearGauge=9,Listbox=10,SpinnerKnob=11,Textbox=12
REM Alignment and Transparencies
CONST Left=0,Center=1,Right=2,Top=0,Middle=1,Bottom=2,Solid=0,Transparent=1
REM Drawing Surfaces
CONST Display=0,Work=1,Background=2
REM Screen Object Event Mask bits
CONST TouchEvents=1,ValueEvents=2,ReleasedEvents=4
REM Screen Object Events
CONST Touched=1,ValueChanged=2,Released=3
REM SpinnerKnob Options
CONST IndicatorLength=0,IndicatorZero=1,IndicatorWidth=2,MinValue=5,MinAngle=6,MaxValue=7,MaxAngle=8
REM + Slider Options
CONST MinOffset=6,MaxOffset=8
REM + Gauge and Icon Options
CONST NumberOfImages=0,Attributes=1,DisableAdvance=1,HAlign=3,VAlign=4
REM + Listbox Options
CONST NumberOfItems=0,TopItem=1,ItemHeight=2
REM + Textbox Options
CONST Style=0,NumberOfChars=1
REM + Textbox Styles
CONST NumbersOnly=1,Password=2,Lowercase=4,Uppercase=8,Readonly=16
```

And here is the resulting screen display:



To use an indicator knob without the spinner don’t supply the spinner bitmap and initialize the three indicator options:

```
10  REM knob with indicator
```

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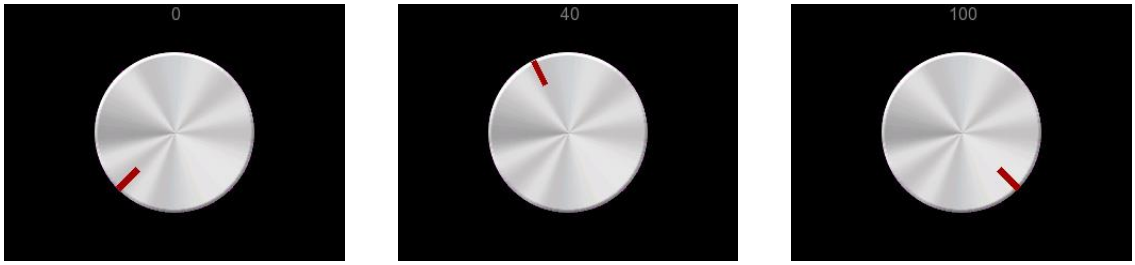
```
15  INCLUDE "constants.bas"
20  @ANSI.ENABLE = False : @BACKLIGHT = True
25  CONST Knob=0 : @SCREEN.OBJ.TYPE[0,Knob] = SpinnerKnob
30  @SCREEN.OBJ.IMAGE$[0,Knob] = "Knob_150x150.bmp"
35  @SCREEN.OBJ.X[0,Knob]=ScreenWidth / 2 - 150 / 2 : @SCREEN.OBJ.Y[0,Knob]=ScreenHeight / 2 - 150 / 2
37  @SCREEN.OBJ.OPTION[0,Knob,IndicatorLength] = 75 : @SCREEN.OBJ.OPTION[0,Knob,IndicatorZero] = 50
38  @SCREEN.OBJ.OPTION[0,Knob,IndicatorWidth] = 5
40  @SCREEN.OBJ.OPTION[0,Knob,MinValue] = 0 : @SCREEN.OBJ.OPTION[0,Knob,MinAngle] = 225
45  @SCREEN.OBJ.OPTION[0,Knob,MaxValue] = 100 : @SCREEN.OBJ.OPTION[0,Knob,MaxAngle] = -45
50  CONST Readout=1 : @SCREEN.OBJ.TYPE[0,Readout]=Label
52  @SCREEN.OBJ.X[0,Readout] = 160-25 : @SCREEN.OBJ.Y[0,Readout] = 220
55  @SCREEN.OBJ.WIDTH[0,Readout] = 50 : @SCREEN.OBJ.HEIGHT[0,Readout] = 20
60  @SCREEN.OBJ.MASK[0,Knob] = ValueChanged : @SCREEN.OBJ.MASK[0,Readout] = None
65  ONEVENT @SCREEN.OBJ.EVENT, GOSUB 10000
100  SCREENS.CHANGETO 0
110  WAIT @SCREEN.EVENT
115  @SCREEN.OBJ.VALUE[0,Knob] = 0
120  GOTO 120
10000  REM screen object event handler
10005  @SCREEN.OBJ.TEXT$[0,Readout] = STR$(@SCREEN.OBJ.VALUE[0,Knob])
10010  RETURN
```

And the result is:



Textbox Object

The Textbox screen object displays the object's .TEXT$ justified within the control's .IMAGE$ bitmap resource.

The width and height of the displayed text area is controlled by the .IMAGE$ width and height or it can be overridden via the .WIDTH and .HEIGHT values. If no .IMAGE$ bitmap resource is specified a box of the configured TPAD_Scheme's off color is drawn outlined by a box of the configured TPAD_Scheme's on color if the object's .SCHEME's .FONT's background is not transparent.

The justification and color of the object's .TEXT$ value is controlled by the font specified object's .SCHEME pair – unfocused is drawn using the first scheme in the pair, focused is drawn using the second scheme in the pair.

If the Textbox is touched, the keypad pops up and the outline rectangle changes from solid to dashed and animates to show that the object has focus. The keypad is popped above or below the control depending upon the control's .Y coordinate so as not to obscure the it. Textboxes that are styled as Numbers Only present the numeric keypad.

The current contents of the .TEXT$ value is selected. Keys that are typed on the popup keypad are entered into the object's .TEXT$ value, replacing the selection. A backspace (Bs) key removes the last key pressed. A carriage return (Enter) key un-focuses the control and hides the pop-up keypad. Each typed key is reported as a change in the screen object's .VALUE along with a value changed event.

There are several textbox styles that are configurable as bit values in the object's .OPTION register. As these are binary weighted bit values they may be combined – for example a password textbox that only accepts numbers would be styled using a value of 1 + 2 = 3. A style of Uppercase only takes precedence over Lowercase only. A style of Read Only performs focusing and keypad pop-up, but the .TEXT$ value cannot be changed by key presses, only by code changes to the .TEXT$ value.

The available textbox style are:

Style bit	*function*
1	Numbers Only

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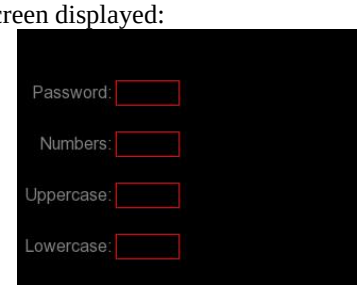
2	Password (only '*' displayed)
4	Lowercase Only
8	Uppercase Only
16	Read Only

Here's a program that shows four textboxes with different styles and four label controls to receive the values entered into the textboxes when the Enter key is pressed.

```
10 REM textboxes
15 @ANSI.ENABLE = 0 : @BACKLIGHT = 1
20 INCLUDE constants.bas
25 CONST EnterKey = 13
30 x = 0 : y = ScreenHeight - 72
35 FOR n = 0 TO 11 STEP 3
40   @SCREEN.OBJ.TYPE[0,(n+0)] = Label
45   @SCREEN.OBJ.X[0,(n+0)] = x : @SCREEN.OBJ.Y[0,(n+0)] = y - ((n/3)*48)
50   @SCREEN.OBJ.WIDTH[0,(n+0)] = 90 : @SCREEN.OBJ.HEIGHT[0,(n+0)] = 24
55   @SCREEN.OBJ.TYPE[0,(n+1)] = Textbox
60   @SCREEN.OBJ.X[0,(n+1)] = x + 93 : @SCREEN.OBJ.Y[0,(n+1)] = y - ((n/3)*48)
65   @SCREEN.OBJ.WIDTH[0,(n+1)] = 60 : @SCREEN.OBJ.HEIGHT[0,(n+1)] = 24
70   @SCREEN.OBJ.MASK[0,(n+1)] = ValueEvents
75   @SCREEN.OBJ.TYPE[0,(n+2)] = Label
80   @SCREEN.OBJ.X[0,(n+2)] = 160 : @SCREEN.OBJ.Y[0,(n+2)] = y - ((n/3)*48)
85   @SCREEN.OBJ.WIDTH[0,(n+2)] = 150 : @SCREEN.OBJ.HEIGHT[0,(n+2)] = 24
90 NEXT n
95 @FONT.HALIGN[0] = Right : @FONT.HALIGN[1] = Right
100 @SCREEN.OBJ.TEXT$[0,0] = "Password:" : @SCREEN.OBJ.OPTION[0,1,Style] = Password
105 @SCREEN.OBJ.TEXT$[0,3] = "Numbers:" : @SCREEN.OBJ.OPTION[0,4,Style] = NumbersOnly
110 @SCREEN.OBJ.OPTION[0,4,NumberOfChars] = 4
115 @SCREEN.OBJ.TEXT$[0,6] = "Uppercase:" : @SCREEN.OBJ.OPTION[0,7,Style] = Uppercase
120 @SCREEN.OBJ.TEXT$[0,9] = "Lowercase:" : @SCREEN.OBJ.OPTION[0,10,Style] = Lowercase
125 ONEVENT @SCREEN.OBJ.EVENT,GOSUB 1000
130 SCREENS.CHANGETO 0
135 WAIT @SCREEN.EVENT
999 GOTO 999
1000 REM screen object event handler
1005 ON @SCREEN.OBJ.EVENT, GOSUB 0,0,1015,0
1010 RETURN
1015 ON @SCREEN.OBJ.#,GOSUB 0,1025,0,0,1045,0,0,1060,0,0,1075,0
1020 RETURN
1025 IF @SCREEN.OBJ.VALUE[0,1] <> EnterKey THEN RETURN
1030 @SCREEN.OBJ.TEXT$[0,2] = @SCREEN.OBJ.TEXT$[0,1] : @SCREEN.OBJ.TEXT$[0,1] = ""
1035 IF @SCREEN.OBJ.TEXT$[0,2] = "exit" THEN 9999
1040 RETURN
1045 IF @SCREEN.OBJ.VALUE[0,4] <> EnterKey THEN RETURN
1050 @SCREEN.OBJ.TEXT$[0,5] = @SCREEN.OBJ.TEXT$[0,4] : @SCREEN.OBJ.TEXT$[0,4] = ""
1055 RETURN
1060 IF @SCREEN.OBJ.VALUE[0,7] <> EnterKey THEN RETURN
1065 @SCREEN.OBJ.TEXT$[0,8] = @SCREEN.OBJ.TEXT$[0,7] : @SCREEN.OBJ.TEXT$[0,7] = ""
1070 RETURN
1075 IF @SCREEN.OBJ.VALUE[0,10] <> EnterKey THEN RETURN
1080 @SCREEN.OBJ.TEXT$[0,11] = @SCREEN.OBJ.TEXT$[0,10] : @SCREEN.OBJ.TEXT$[0,10] = ""
1085 RETURN
9999 END
```

When the program is started this is the screen displayed:



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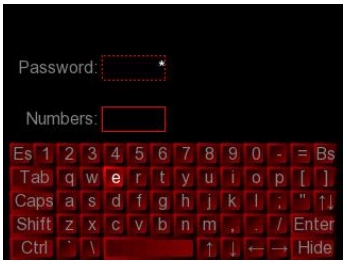
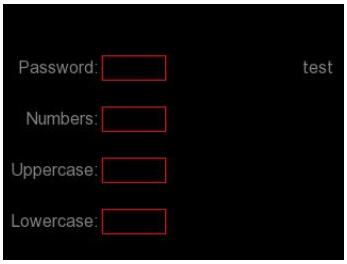
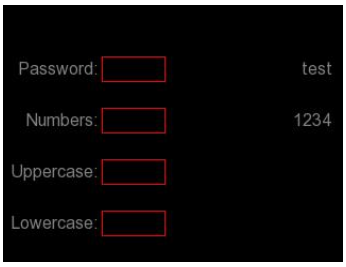
Touching the Password textbox pops up the keypad, and animates the textbox rectangle indicating that the control has focus. Pressed keys are entered in password style until the Enter key is pressed then the control's .TEXT$ content is transferred to the label control on the same line and the textbox is cleared:





Touching the Number textbox pops up the numeric keypad and animates the textbox rectangle indicating that the control has focus. Pressed keys are entered until the Enter key is pressed then the control's .TEXT$ content is transferred to the label control on the same line and the textbox is cleared:



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@SCREEN.OBJ.SCHEME[screen, object]

This system variable sets the Scheme table entry of the scheme or lower entry of the Scheme pair that is used to render this screen object table entry.

@SCREEN.OBJ.X[screen, object]

This system variable sets the X coordinate of the position of the screen object relative to the screen for this screen object table entry.

@SCREEN.OBJ.Y[screen, object]

This system variable sets the X coordinate of the position of the screen object relative to the screen for this screen object table entry.

@SCREEN.OBJ.VALUE[screen, object]

This system variable sets or retrieves the value associated with the screen object for this screen object table entry The values are specific to each @SCREEN.OBJ.TYPE.

TBD – need descriptions of all of the Object Types and how their values interact here.

@SCREEN.OBJ.TOUCHED[screen, object]

This system variable sets or retrieves the touch state associated with the screen object for this screen object table entry.

@SCREEN.OBJ.IMAGE$[screen, object]

This system variable sets or retrieves the image resource used to render the screen object for this screen object table entry.

@SCREEN.OBJ.OVERLAY$[screen, object]

This system variable sets or retrieves the overlay image resource used to render the screen object for this screen object table entry.

@SCREEN.OBJ.TEXT$[screen, object]

This system variable sets or retrieves the optional text resource used to render the screen object for this screen object table entry.

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@SCREEN.OBJ.OPTION[screen, object, option]

This system variable sets or retrieves the option values used to render the screen object for this screen object table entry. Here are the currently defined option values for the defined object types:

Icon Screen Object	
option	***function***
0	Number of Images override
1	Attributes: 1 Disable Touch Advance
2	
3	Horizontal Alignment: 0 Left 1 Center 2 Right
4	Vertical Alignment: 0 Bottom 1 Middle 2 Top
5	
6	
7	
8	
9	

Button Screen Object	
option	***function***
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

Toggle Button Screen Object	
option	***function***
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

Back Button Screen Object	
option	***function***
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

Slider Screen Object	
option	***function***
0	
1	
2	
3	
4	
5	Minimum Value
6	Minimum Offset
7	Maximum Value
8	Maximum Offset
9	

Label Screen Object	
option	***function***
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

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Touch Keypad Screen Object	
option	***function***
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

Linear Gauge Screen Object	
option	***function***
0	Needle Length
1	Needle Zero
2	Needle Width
3	Needle Horizontal Alignment: 0 Left 1 Center 2 Right
4	Needle Vertical Alignment: 0 Bottom 1 Middle 2 Top
5	Minimum Angle
6	Minimum Value
7	Maximum Angle
8	Maximum Value
9	

Radial Gauge Screen Object	
option	***function***
0	Needle Length
1	Needle Zero
2	Needle Width
3	Needle Horizontal Alignment: 0 Left 1 Center 2 Right
4	Needle Vertical Alignment: 0 Bottom 1 Middle 2 Top
5	Minimum Angle
6	Minimum Value
7	Maximum Angle
8	Maximum Value
9	

Listbox Screen Object	
option	***function***
0	Number of Data Items
1	Top Item
2	Item Height Override
3	
4	
5	
6	
7	
8	
9	

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Spinner Knob Screen Object	
option	***function***
0	Indicator Length
1	Indicator Zero
2	Indicator Width
3	
4	
5	Minimum Angle
6	Minimum Value
7	Maximum Angle
8	Maximum Value
9	

Textbox Screen Object	
option	***function***
0	Styles: 1 Numbers Only 2 Password (only '*' displayed) 4 Lowercase 8 Uppercase 16 Read Only
1	Maximum Number of Characters
2	
3	
4	
5	
6	
7	
8	
9	

@SCREEN.OBJ.#

This read-only system variable reflects the screen object number of the last screen object event.

@SCREEN.OBJ.EVENT

This system variable reflects the last screen object event. There are currently three screen object events:

@SCREEN.OBJ.EVENT	Event
1	Screen Object[@SCREEN.#, @SCREEN.OBJ.#] was touched
2	Screen Object[@SCREEN.#, @SCREEN.OBJ.#] value has changed
3	Screen Object[@SCREEN.#, @SCREEN.OBJ.#] was un-touched (released)

@SCREEN.OBJ.MASK

This system variable gets or sets the screen object event mask. There is one bit to enable or disable each of the screen object events – a set bit enables the event. The default @SCREEN.OBJ.MASK is all events enabled:

Where the bits are numbered:

15 MSB	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0 LSB

Bit #	# Value	@SCREEN.OBJ.EVENT
0	1	Screen object touched
1	2	Screen object value changed
2	4	Screen object un-touched (released)

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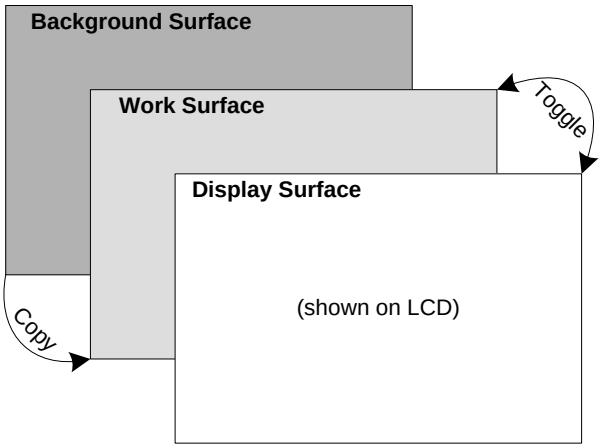
@SURFACE

This system variable sets the drawing surface for subsequent DRAW. commands. There are three drawing surfaces:

@SURFACE	Drawing Surface
0	Display
1	Work
2	Background



@TOUCH.

These system variables allow program interaction with the display touchscreen and pop-up keypad:

@TOUCH.KEYPAD

This system variable is event capable, is fired whenever a touch keypad event occurs and gets or sets the pop-up touch keypad status:

@TOUCH.KEYPAD	Keypad
0	no keypad
1	QWERTY keypad
2	Numeric keypad
3	QWERTY keypad top
4	Numeric keypad top
5	Configuration keypad

@TOUCH.EVENT

This system variable is event capable and is fired whenever a touchscreen event occurs:

@TOUCH.EVENT	Event
0	no event
1	touchscreen press event
2	touchscreen move event
3	touchscreen release event

@TOUCH.X

This system variable holds the X coordinate of the @TOUCH.EVENT

@TOUCH.Y

This system variable holds the Y coordinate of the @TOUCH.EVENT

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Events

ACS Basic provides the concept of an ***Event***. Events occur outside of the normal program execution flow and are processed in between the execution of individual program statements. Some system variables have ***Events*** associated with them and may be referenced in **ONEVENT, SIGNAL** and **WAIT** statements. There are three ways to process an event: asynchronously with an **ONEVENT** handler, synchronously with a **WAIT** statement or by polling the system variable's value in the program to see when the event occurs.

In order to process an event asynchronously, Basic has to be informed of what code to execute when a certain event occurs. This is done using the **ONEVENT** statement. After Basic executes each program statement, it scans the table of events looking to see if any have been signaled. If an **ONEVENT** handler for a signaled event has been specified by the program, then Basic will force a subroutine call to the event handler before the next program statement is executed.

Events have an implicit priority with higher priority events being able to interrupt execution of lower priority event handlers. Here is an example of touch event handling:

```
100 REM Test Touch Events
110 ONEVENT @TOUCH.EVENT, GOSUB 1000
130 GOTO 130
1000 T=@TOUCH.EVENT: X=@TOUCH.X: Y=@TOUCH.Y
1010 ON T, GOTO 1015,1020,1025,1030
1015 RETURN
1020 PRINT "Touch   @ ";X;", ";Y : RETURN
1025 PRINT "Move    @ ";X;", ";Y : RETURN
1030 PRINT "Release @ ";X;", ";Y : RETURN
1035 RETURN
Ready
```

This would print **"Touch @ x, y", "Move @ x, y", or "Release @ x, y"** on the screen as the user interacts with the touchscreen.

The **SIGNAL** statement may be used in a program to force an event to happen.

It is very important to note that the **ONEVENT** handler subroutine executes in the context of the running program: it has access to all program variables. Since the event handler may be executed at any time in between any program statements care should be used when changing program variables from within an event handler as it may cause unexpected results in the execution of other program statements that may be using and depending upon the values of those same variables. Incorrect or unexpected program execution may result – code event handlers carefully.

See the **ONEVENT** statement definition below for a table showing what graphic events may be processed and listing their relative priority.

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Acs Basic Graphics Statements

The following statements operate directly or indirectly on the display. There are statements to manage resources such as fonts and images, perform drawing operations and configure and manage a higher-level screen setup.

ONEVENT @systemvar, GOSUB line

ONEVENT @systemvar, GOSUB `label

Program mode only. Provides semi-asynchronous event handling via subroutines. Certain ACS Basic graphics system variables can trigger events. The **ONEVENT** statement allows the event to be associated with the execution of a subroutine.

When the event occurs, after execution of any current statement that does not transfer control, control is transferred to the subroutine starting at ***line*** or ***`label***.

*While in the event subroutine, only higher priority events will be recognized until after the **RETURN** statement is executed.*

An event handler can be disabled by specifying a ***line*** number of zero. Executing the **ONEVENT** statement clears the associated event in preparation for the subsequent event handling.

The following graphics system variables can cause events and are listed in order of ***decreasing*** priority:

@TOUCH.KEYPAD	The event triggers upon a change in the display touch keypad status.
@TOUCH.EVENT	The event triggers upon user touch interaction with the display touchscreen.
@SCREEN.OBJ.EVENT	The event triggers upon user touch interaction with the screen object.
@SCREEN.EVENT	The event triggers as each @SCREEN is displayed or hidden.

Events have an implicit priority with higher priority events being able to interrupt execution of lower priority event handlers. Here is an example of touch event handling:

```
100 REM Test Touch Events
110 ONEVENT @TOUCH.EVENT, GOSUB 1000
130 GOTO 130
1000 T=@TOUCH.EVENT: X=@TOUCH.X: Y=@TOUCH.Y
1010 ON T, GOTO 1015,1020,1025,1030
1015 RETURN
1020 PRINT "Touch   @ ";X;", ";Y : RETURN
1025 PRINT "Move    @ ";X;", ";Y : RETURN
1030 PRINT "Release @ ";X;", ";Y : RETURN
1035 RETURN
Ready
```

This would print **"Touch @ x, y", "Move @ x, y", or "Release @ x, y"** on the screen as the user interacts with the touchscreen.

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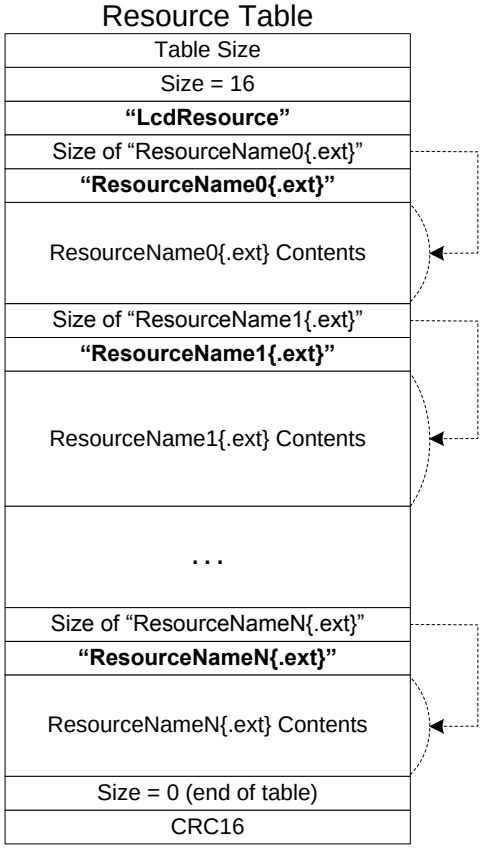
RESOURCES

The display uses ‘resources’ to provide fonts, bitmaps and sounds in this mode. These resources are loaded into a ‘table’ in RAM where they can be rapidly accessed by the different commands that require them.

This resource table can be loaded from the flash memory and/or from the SD card upon reset, or dynamically from the SD card during operation depending upon the device. The table is searched from the beginning when resources are accessed, with newly added resources located at the front of the table.

Each entry in the table consists of the size of the resource, its name– including any extension, and then the resource contents. The entire Resource Table is protected by a cyclic redundancy check value of its contents. Dynamically added resources are added to the front of the Resource Table:



RESOURCES.INIT

Initializes the Resource table, clearing all entries.

RESOURCES.LIST {pattern}

Prints a list of the current contents of the Resource table. Wildcards ‘*’ and ‘?’ may be used in an optional pattern to select which resources are listed.

RESOURCES.LOAD filename{.bin}

Initializes then loads the Resource table from the binary file on the SD card. The binary resource file image can be generated by an ACS Windows utility that supports the concept of resource generation projects (.RSRCGEN XML project files). (***See the appendix Resource File Generation in the Color_320x240_LCD_ Terminal manual)***

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RESOURCES.SAVE filename{.bin}

Saves the current contents of the Resource table as a binary file on the SD card.

RESOURCES.ADD filename

Adds the contents of filename from the SD card to the beginning of the Resource table. Duplicate resources with the same name are not allowed.

RESOURCES.REMOVE resourceName

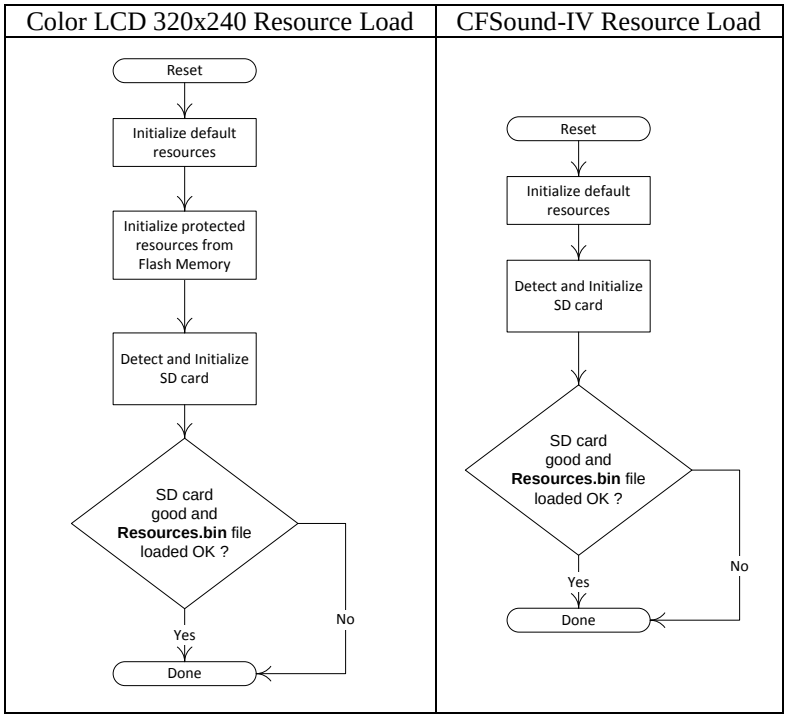
Removes the resource named resourceName from the Resource table.

RESOURCES.EXTRACT {pattern}

Extract the current contents of resources in the Resource table that match the pattern to the SD card. Wildcards '*' and '?' may be used in an optional pattern to select which resources are extracted. The user is prompted for existing file overwrite permission.

Initial Resource Table Load

When the ACS device is powered-up or reset, it attempts to locate and load the resource table from flash memory and the SD card. This process is outlined in the following flowchart:



1. The AcsDefaultFont.efnt (used for the diagnostics and keypad keys), the AcsAnsiFont.efnt and the button bitmaps (used for the keypad keys) resources are loaded from internal processor memory.
2. If the product has flash memory any resources located in a protected area are loaded.
3. The SD card is detected and, if present, the file system is initialized.
4. If the SD card was detected and initialized in step 3 attempt to load the binary resources file named: Resources.bin. If it loads and verifies then initial resource table loading is complete.

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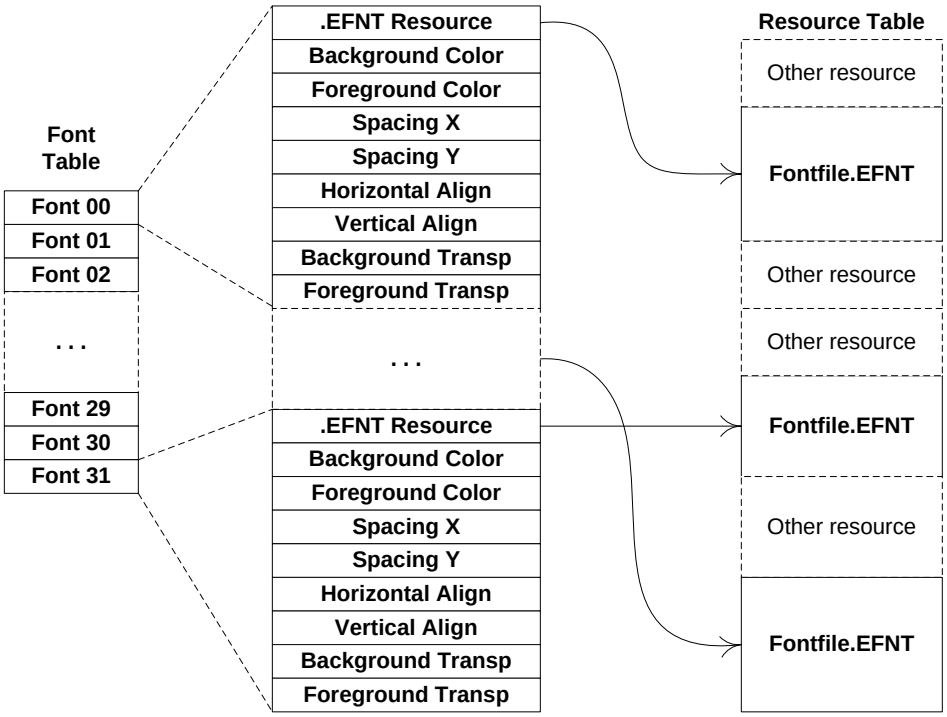
FONTS

The appearance of all text that is drawn on the display is controlled by fonts selected from a font table. The character images are extracted from previously constructed and loaded .EFNT resources. Each table entry holds the Font Name (.EFNT resource name), several attributes for horizontal and vertical alignment, spacing and background/foreground colors and transparency.

The table holds 32 entries. The table entry number is used as the selector of the font for drawing and display access.



The following commands are provided to manage the contents of the Font table.

FONTS.INIT

Initializes the Font table, setting all of the entries to defaults.

FONTS.LIST {start{, end}} … FONTS.LIST {start{-end}}

Prints a list of the current contents of the Font table. May also specify a starting and ending font number to select which font numbers to list.

FONTS.LOAD filename{.fonts}

Loads the Font table from a JSON formatted file on the SD card***. (See the appendix JSON File Formats in the Color 320x240 LCD Terminal User's Manual)***

FONTS.SAVE filename{.fonts}

Saves the current contents of the Font table to a JSON formatted file on the SD card. ***(See the appendix JSON File Formats in the Color 320x240 LCD Display Terminal User's Manual)***

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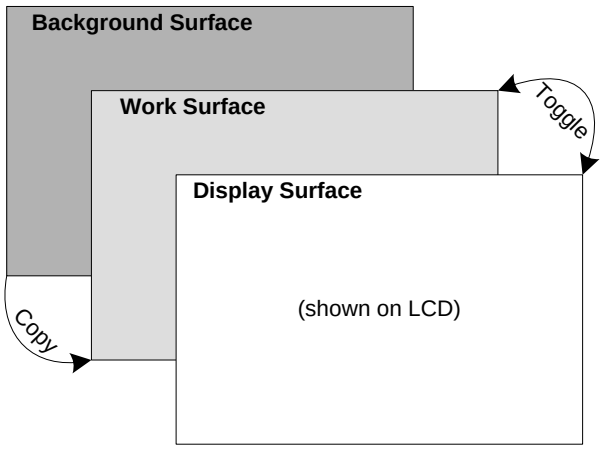
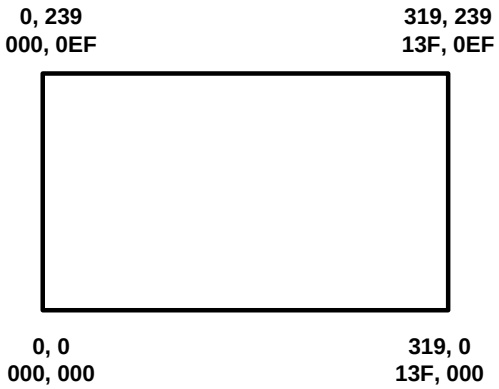
DRAWING

There are three drawing surfaces: Display, Work and Background. The Display surface is the one that is currently being shown on the virtual display. The Work surface is where most drawing is done before being swapped with the Display surface. The Background surface provides a content area that can be seldom drawn, and copied to the Work surface before additional drawing is done on top.



All drawing takes place on the currently selected draw surface. Commands are provided to render pixels, lines, fills, boxes, circles, ellipses, text and images.

The X and Y coordinate for drawing start at **0, 0** at the lower left corner of the Virtual display:



Drawing is clipped at the coordinate boundaries of the virtual display.

In order to avoid flickering as the virtual display is updated the following sequence should be utilized:

7. Switch to the Background draw surface.
8. Draw any required static background content.
9. Switch to the Work surface.
10. Copy in the content from the Background surface to the Work surface and draw any dynamic content on top of it.
11. Toggle the Work and Display surfaces.
12. Repeat from step 4.

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DRAW.INIT

Initializes the drawing system: clears the three drawing surfaces, restores the @ANSI system variables to their default values, sets the current drawing @SURFACE as DISPLAY.

DRAW.COPY sourceSurface, sX, sY, dX, dY, width, height

Copies the region located at sX,sY, of width and height from the specified source surface to the current drawing @SURFACE at dX, dY.

DRAW.TRANSLATE sourceSurface, sX, sY, dX, dY, width, height, mode

Translates the region located at sX,sY, of width and height from the source surface to the current drawing @SURFACE at dX, dY using mode.

Where:

mode	Operation
0	No rotation
1	Rotate 90 CCW
2	Rotate 180 CCW
3	Rotate 270 CCW
+4	Flip horizontal
+8	Flip vertical

Here is a sample program that displays the time once per second and shows three copies of the seconds portion each rotated by 90 degrees:

```
10 REM demo draw.translate
15 @ANSI.ENABLE = 0:@ANSI.CURSOR = 0:@BACKLIGHT = 1
20 REM configure font[0]
25 @FONT.EFNT$[0]="Fnt-LiquidCrystal64.efnt":@FONT.FCOLOR[0]=RGB(255,255,255)
30 @FONT.BTRANSP[0] = 1 : @FONT.HALIGN[0] = 1 : @FONT.VALIGN[0] = 1
35 REM draw filled box on background
40 @SURFACE = 2 : DRAW.BOX.FILLED 30, 100, 290, 180, RGB(255,0,0) : @SURFACE = 1
45 REM init @SECOND event handler
50 ONEVENT @SECOND,GOSUB 1005
55 GOTO 55
1000 REM @SECOND event handler
1005 t$ = FMT$("%02d",@HOUR) + ":" + FMT$("%02d",@MINUTE) + ":" + FMT$("%02d",@SECOND)
1010 REM copy background to work, draw current time on work
1015 DRAW.COPY 2, 30, 100, 30, 100, 260, 150 : DRAW.TEXT 0, 160, 140, t$
1020 REM translate and rotate seconds on work
1025 DRAW.TRANSLATE 1, 210, 100, 0, 0, 80, 80, 1
1030 DRAW.TRANSLATE 1, 210, 100, 120, 0, 80, 80, 2
1035 DRAW.TRANSLATE 1, 210, 100, 240, 0, 80, 80, 3
1040 REM toggle work and display
1045 DRAW.TOGGLE
1050 RETURN
```

And the resulting screen display:

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DRAW.TOGGLE

Toggles the DISPLAY and WORK drawing surfaces – WORK becomes DISPLAY and DISPLAY becomes WORK. This is useful for double-buffer or ping-pong drawing to minimize flickering.

DRAW.PIXEL x, y, color

Sets the virtual display pixel at location x, y on the current drawing @SURFACE to color.

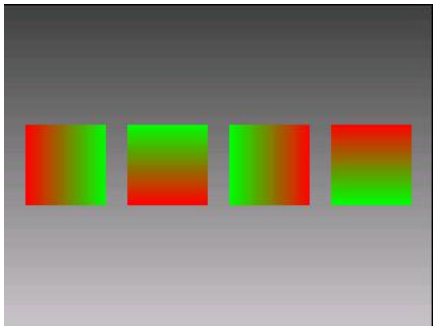
DRAW.FILL x, y, width, height, color {, endcolor, angle}

Fills the virtual display starting at x, y for width and height with color. If endcolor and angle arguments are present fills as a gradient from color to endcolor at angle. Angle can be 0, 90, 180 or 270.

Here is a sample program that shows an overall gradient fill, then smaller fills at the four different angles:

```
10 REM DRAW.FILL demo
15 @ANSI.ENABLE = 0 : @BACKLIGHT = 1
20 DRAW.FILL 0, 0, 319, 239, RGB(192,192,192), RGB(64,64,64), 90
25 DRAW.FILL 16, 90, 60, 60, RGB(255,0,0),RGB(0,255,0),0
30 DRAW.FILL 92, 90, 60, 60, RGB(255,0,0),RGB(0,255,0), 90
35 DRAW.FILL 168, 90, 60, 60, RGB(255,0,0),RGB(0,255,0), 180
40 DRAW.FILL 244, 90, 60, 60, RGB(255,0,0),RGB(0,255,0), 270
50 GOTO 50
```

And the resulting screen display:



DRAW.LINE startX, startY, endX, endY, color

Draws a line of color from startX, startY to endX, endY.

DRAW.LINE.DASHED startX, startY, endX, endY, color, pattern, scale

Draws a dashed line of color from startX, startY to endX, endY. Each bit in the pattern is used scale times to draw the pixels in the line; a pattern of 21845 (hex 5555) (binary 0101010101010101) with a scale of 4 would draw 4 pixel dashes, 4 pixels apart.

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DRAW.ARC x, y, width, height, startDegrees, endDegrees, color

Draws an arc centered at x, y of width and height through angle startDegrees to endDegrees using color.

DRAW.ARC.STYLED x, y, width, height, startDegrees, endDegrees, color, style

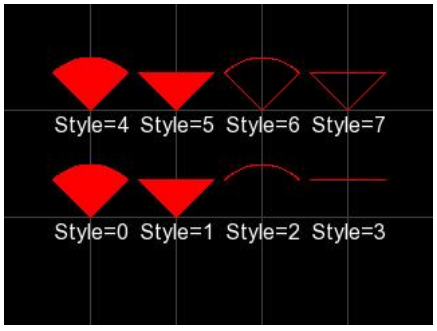
Draws an arc centered at x, y of width and height through angle startDegrees to endDegrees using color styled by the following style bits – zero degrees is right and angle advances counter-clockwise:

Style Bit	Name
1	Chord
2	No Fill
4	Edged

Here is a sample program that shows the results of combining the various style bits:

```
10 REM arc demo
20 @ANSI.ENABLE=0
30 REM draw grid
40 FOR x = 64 TO 256 STEP 64 : DRAW.LINE x,0,x,239,RGB(64,64,64) : NEXT x
50 FOR y = 80 TO 160 STEP 80 : DRAW.LINE 0,y,319,y,RGB(64,64,64) : NEXT y
60 REM init text font
70 @FONT.HALIGN[0]=1 : @FONT.VALIGN[0]=2 : @FONT.FCOLOR[0]=RGB(255,255,255)
80 REM draw eight styles of filled arcs
90 DRAW.ARC.FILLED 64,80,80,80,45,135,RGB(255,0,0),0
100 DRAW.TEXT 0,64,80,"Style=0"
110 DRAW.ARC.FILLED 128,80,80,80,45,135,RGB(255,0,0),1
120 DRAW.TEXT 0,128,80,"Style=1"
130 DRAW.ARC.FILLED 192,80,80,80,45,135,RGB(255,0,0),2
140 DRAW.TEXT 0,192,80,"Style=2"
150 DRAW.ARC.FILLED 256,80,80,80,45,135,RGB(255,0,0),3
160 DRAW.TEXT 0,256,80,"Style=3"
170 DRAW.ARC.FILLED 64,160,80,80,45,135,RGB(255,0,0),4
180 DRAW.TEXT 0,64,160,"Style=4"
190 DRAW.ARC.FILLED 128,160,80,80,45,135,RGB(255,0,0),5
200 DRAW.TEXT 0,128,160,"Style=5"
210 DRAW.ARC.FILLED 192,160,80,80,45,135,RGB(255,0,0),6
220 DRAW.TEXT 0,192,160,"Style=6"
230 DRAW.ARC.FILLED 256,160,80,80,45,135,RGB(255,0,0),7
240 DRAW.TEXT 0,256,160,"Style=7"
999 GOTO 999
```

And the resulting screen virtual display:



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DRAW.BOX x1, y1, x2, y2, color

Draws a box with corners at x1, y1 and x2, y2 using color.

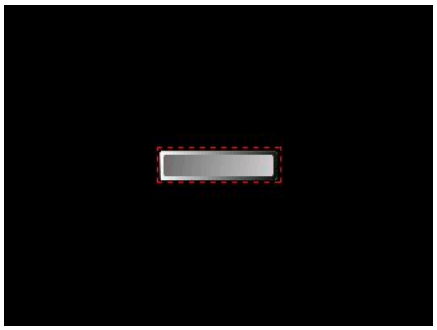
DRAW.BOX.DASHED x1, y1, x2, y2, color, pattern, scale

Draws a dashed line box with corners at x1, y1 and x2, y2 using color. Each bit in the pattern is used scale times to draw the pixels in the box lines; a pattern of 21845 (hex 5555) (binary 0101010101010101) with a scale of 4 would draw the box using 4 pixel dashes, 4 pixels apart.

Here is a sample that draws a 'crawling ants' flashing line around a bitmap button:

```
10 REM DRAW.BOX.DASHED demo
15 @ANSI.ENABLE = 0 : @BACKLIGHT = 1
20 xc = 160 : yc = 120 : w = BITMAP.WIDTH("ButtonK4.bmp") : h = BITMAP.HEIGHT("ButtonK4.bmp")
25 @SURFACE = 2 : DRAW.BITMAP xc - w/2, yc - h/2, "ButtonK4.bmp" : @SURFACE = 1
30 blx = xc-(w/2)-2 : bly = yc-(h/2)-2 : bux = xc+(w/2)+2 : buy = yc+(h/2)+2
35 ONEVENT @TIMER[0], GOSUB 1000
40 @TIMER[0] = 10
45 GOTO 45
1000 DRAW.COPY 2, blx, bly, blx, bly, w + 4, h + 4
1005 IF pattern = HEX.VAL("5555") THEN pattern = HEX.VAL("AAAA") ELSE pattern = HEX.VAL("5555")
1010 DRAW.BOX.DASHED blx, bly, bux, buy, RGB(255,0,0), pattern, 4
1020 DRAW.TOGGLE
1025 @TIMER[0] = 10
1030 RETURN
```

And the resulting screen display:



DRAW.BOX.FILLED x1, x2, y1, y2, color

Draws a filled box with corners at x1, y1 and x2, y2 using color.

DRAW.CIRCLE x, y, r, color

Draws a circle centered at x, y of radius r using color.

DRAW.ELLIPSE x, y, width, height, color

Draws an ellipse centered at x, y of width and height using color.

DRAW.ELLIPSE.FILLED x, y, width, height, color

Draws a filled ellipse centered at x, y of width and height using color.

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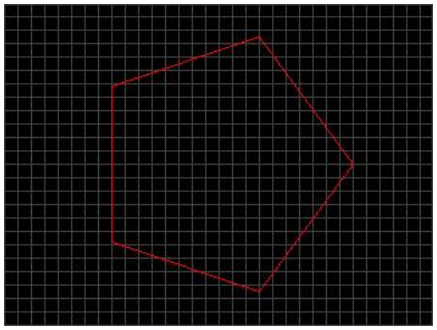
DRAW.POLYGON x[n], y[n],color

Draws an 'n' sided polygon with the x and y array of vertices using color where n ≥ 3. Here is a sample program that draws regular polygons:

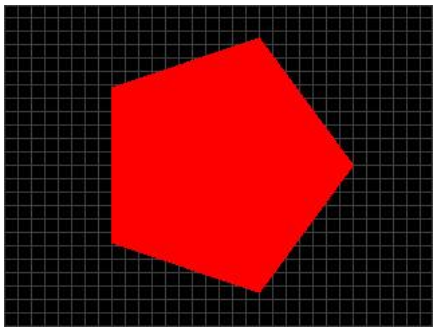
```
10 REM demo draw.polygon
15 @ANSI.ENABLE = 0 : @BACKLIGHT = 1
20 GOSUB 1000
25 INPUT "how many sides ? ", n : IF n <= 0 THEN STOP
30 GOSUB 1000
35 radius = 100 : xc = 160 : yc = 120
40 DIM x[n], y[n]
45 FOR i = 0 TO n-1
50 x[i] = MULDIV(radius, COS((360 * i) / n), 1024) + xc
55 y[i] = MULDIV(radius, SIN((360 * i) / n), 1024) + yc
60 NEXT i
65 DRAW.POLYGON x, y, RGB(255,0,0)
70 GOTO 25
1000 REM draw grid
1005 DRAW.FILL 0,0,319,239,RGB(0,0,0)
1010 FOR xg = 0 TO 320 STEP 10 : DRAW.LINE xg, 0, xg, 239, RGB(64,64,64) : NEXT xg
1015 DRAW.LINE 319,0,319,239,RGB(64,64,64)
1020 FOR yg = 0 TO 240 STEP 10 : DRAW.LINE 0, yg, 319, yg, RGB(64,64,64) : NEXT yg
1025 DRAW.LINE 0,239,319,239,RGB(64,64,64)
1030 RETURN
Ready
run
how many sides ? 5
how many sides ? 0
STOP in line 25
Ready
```

And the resulting screen display:



DRAW.POLYGON.FILLED x[n], y[n],color

Draws an 'n' sided filled polygon with the x and y array of vertices using color where n ≥ 3. Try changing line 65 in the DRAW.POLYGON example above:



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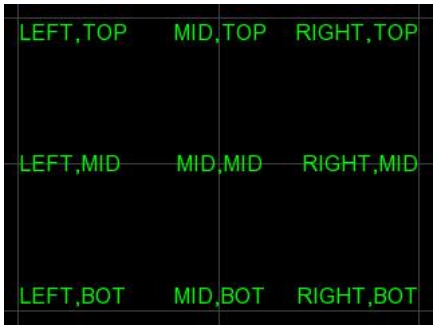
DRAW.TEXT font, x, y, expression

Draws the text string of the expression justified at x, y using the attributes of Font table entry font.

Here is a sample program that shows how the font's .HALIGN and .VALIGN system variables affect the text display:

```
10 REM demo DRAW.TEXT and @FONT.HALIGN, @FONT.VALIGN
15 @ANSI.ENABLE = 0 : @ANSI.CURSOR = 0 : @BACKLIGHT = 1
20 REM Draw grid
25 DRAW.LINE 10,0,10,239,RGB(64,64,64)
30 DRAW.LINE 160,0,160,239,RGB(64,64,64)
35 DRAW.LINE 309,0,309,239,RGB(64,64,64)
40 DRAW.LINE 0,10,319,10,RGB(64,64,64)
45 DRAW.LINE 0,120,319,120,RGB(64,64,64)
50 DRAW.LINE 0,229,319,229,RGB(64,64,64)
55 REM Draw aligned text in green
60 @FONT.FCOLOR[0] = RGB(0,255,0)
65 @FONT.HALIGN[0]=0:@FONT.VALIGN[0]=0:DRAW.TEXT 0,10,10,"LEFT,BOT"
70 @FONT.HALIGN[0]=1:@FONT.VALIGN[0]=0:DRAW.TEXT 0,160,10,"MID,BOT"
75 @FONT.HALIGN[0]=2:@FONT.VALIGN[0]=0:DRAW.TEXT 0,309,10,"RIGHT,BOT"
80 @FONT.HALIGN[0]=0:@FONT.VALIGN[0]=1:DRAW.TEXT 0,10,120,"LEFT,MID"
85 @FONT.HALIGN[0]=1:@FONT.VALIGN[0]=1:DRAW.TEXT 0,160,120,"MID,MID"
90 @FONT.HALIGN[0]=2:@FONT.VALIGN[0]=1:DRAW.TEXT 0,309,120,"RIGHT,MID"
95 @FONT.HALIGN[0]=0:@FONT.VALIGN[0]=2:DRAW.TEXT 0,10,229,"LEFT,TOP"
100 @FONT.HALIGN[0]=1:@FONT.VALIGN[0]=2:DRAW.TEXT 0,160,229,"MID,TOP"
105 @FONT.HALIGN[0]=2:@FONT.VALIGN[0]=2:DRAW.TEXT 0,309,229,"RIGHT,TOP"
110 GOTO 110
```

And the resulting screen display:



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DRAW.BITMAP x, y, “imageResourceName”

Draws the named bitmap image from the resource table with the lower left corner located at x, y.

Here is a sample. The RESOURCES.LIST command is used to see what bitmap resources named starting with “Background”. One of these named resources is then drawn on the display:

```
resources.list background*.bmp
Background_DateTimeScreen.bmp        153,676
Background_HomeScreenWithACSLogo.bmp 153,676
Background_PoolScreen.bmp            153,676
Background_TimerEditScreen.bmp       153,676
Background_TimersScreen.bmp          153,676
Ready
list
10 REM DRAW.BITMAP demo
15 @ANSI.ENABLE = 0 : @BACKLIGHT = 1
20 DRAW.BITMAP 0, 0, "Background_HomeScreenWithACSLogo.bmp"
25 GOTO 25
Ready
run
```

And the resulting screen:

DRAW.BITMAP.INDEXED index, x, y, “imageResourceName”

Draws a portion of the horizontally stacked bitmap image from the resource table selected by index at x, y. The stacked image must be square (based upon the image height). The number of instances or portions contained in the image equals the image width divided by the image height.
This command can be used to implement an animated image by changing the index and redrawing the image based upon on a timer event, or an indicator that can change its appearance upon some condition.

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DRAW.BITMAP.TRANSP mode, color, x, y, “imageResourceName”

Draws a bitmap image from the resource table using transparency mode and color at x, y:

Where:

mode	Operation	color	Description
0	Magic Value	Magic index or magic color	For indexed .BMP images the index value corresponding to the magic color For 16bpp .BMP images the RGB565 magic color.
1	None	Not used	Surface pixel = image pixel
2	Darken	RGB565 color to be used as a multiplier	Surface pixel = surface pixel * RGB565 color (can darken image)
3	Source Color Filter	Not used	Surface pixel = surface pixel * image pixel (5:6:5 channel by channel multiply) (color filter from image)
4	Source Alpha Mask	RGB565 color to be used as a ‘white’ replacement	Surface pixel = (surface pixel * RGB565 color) + (1 – image pixel) * surface pixel (treats image as an alpha mask, white solid, black transparent, intermediate blended)
5	Fill	RGB565 fill color	Surface pixel = RGB565 color
6	Transparency Blend	RGB565 color to use as an Alpha multiplier	Surface pixel = (RGB565 color * image pixel) + (1 – RGB565 color) * surface pixel (blends image into surface by ratio determined by RGB565 color)
7	Shadow	RGB565 color to use as an Alpha multiplier	Surface pixel = (RGB565 color * image pixel * surface pixel) + (1 – image pixel) * surface pixel (image is mask to apply multiplication of RGB565 color)

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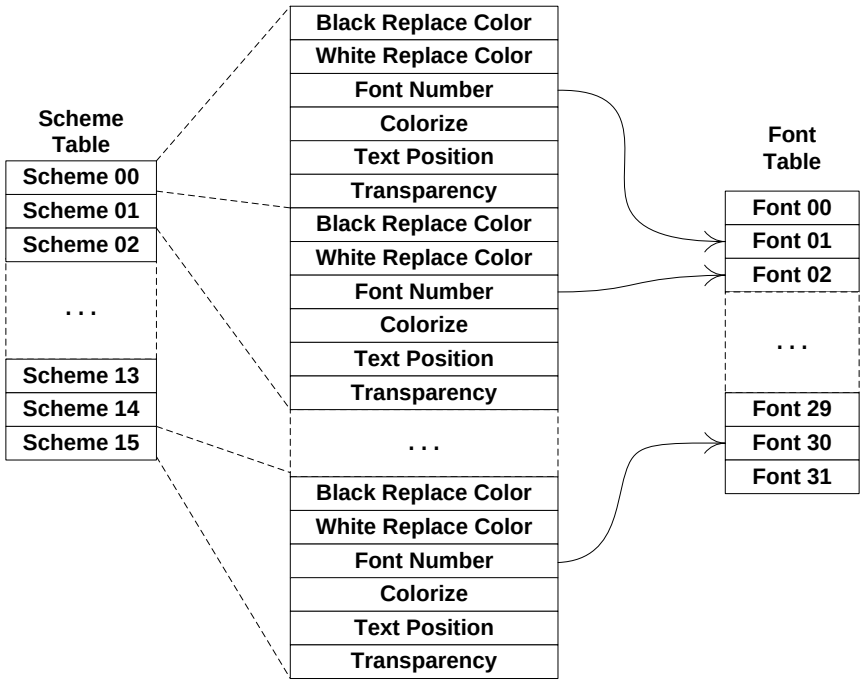
SCHEMES

Schemes are implemented to provide a common way to label and colorize all higher level screen objects such as buttons, sliders and icons. Schemes are used in pairs with the first element of the pair used for rendering the screen object when it isn't touched, and the second used to render the object when it is touched. The two replacement colors can provide colorization of gray scale buttons that changes when the buttons are touched and released. The schemes are stored in a table and are referenced by the entry number.

There sixteen entries in the Schemes table yielding eight scheme pairs.



The following commands are provided to manage the contents of the Schemes table:

SCHEMES.INIT

Initializes the Schemes table.

SCHEMES.LIST

Lists the contents of the Schemes table.

SCHEMES.LOAD filename{.schemes}

Loads the Schemes table from a JSON formatted file on the SD card. ***(See the appendix JSON File Formats in the Color 320x240 LCD Display Terminal User's Manual)***

SCHEMES.SAVE filename{.schemes}

Saves the Schemes table to a JSON formatted file on the SD card. ***(See the appendix JSON File Formats in the Color 320x240 LCD Display Terminal User's Manual)***

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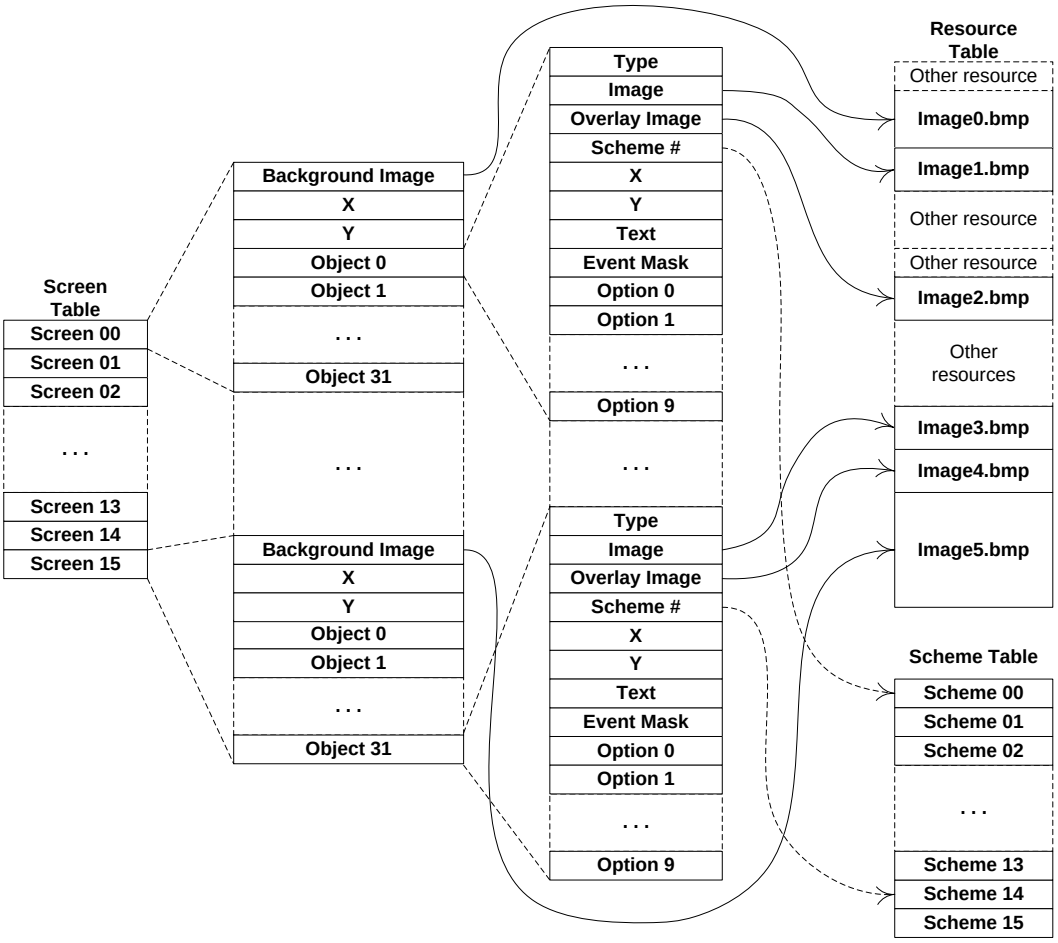
SCREENS

Screens are implemented to provide a grouped collection of placed screen objects such as buttons, sliders and icons overlaid on top of a background image. Screens are drawn entirely by the display including the automatic colorization of objects as they are manipulated with the interactions reported as events.

The screens may be navigated to directly by their number or like a stack – last in, first out. Events are fired when screens are navigated to or away from. The screens are stored in a table and are referred to by their entry number.

There are sixteen entries in the Screen table and each screen can contain up to thirty two screen objects. Object entries in the Screen table must be contiguous – screen objects will not be processed beyond the first zero entry.



The individual fields in the Screens table are accessed via the @SCREEN system variables which are indexed by the screen number.

The individual fields in the Screen Objects in each screen are accessed via the @SCREEN.OBJ system variables which are indexed by both the screen number and screen object number.

The following commands are provided to manage the contents of the Screens table:

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SCREENS.INIT

Initializes the Screens table.

SCREENS.LIST

Lists the contents of the Screens table.

SCREENS.LOAD filename{.screens}

Loads the Screens table from a JSON formatted file on the SD card. (See the appendix JSON File Formats in the Color 320x240 LCD Display Terminal User's Manual)

SCREENS.SAVE filename{.screens}

Saves the Screens table to a JSON formatted file on the SD card. (See the appendix JSON File Formats in the Color 320x240 LCD Display Terminal User's Manual)

The following commands are provided to operate the Screen system:

SCREENS.CHANGETO screenNumber

Constructs and displays the contents of the Screens table screenNumber entry. Changing to the first screen is used to startup the operation of the Screens system. Before any DRAWing command can be used after a SCREENS.CHANGETO the screen has to be fully constructed as indicated by the @SCREEN.EVENT system variable / event being signaled.

SCREENS.PUSHTO screenNumber

Saves the currently displayed Screens table entry number on a stack, deconstructs the current screen and then constructs and displays the contents of the of the Screens table screenNumber entry.

SCREENS.POP

Deconstructs the current screen and then restores the last pushed to Screens table entry number from the stack then constructs and displays it.

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Graphics Support Functions

ACS Basic provides several graphics support functions that may be used in expressions. There must not be a space between the function name and the opening parenthesis. Functions must be used in a statement such as a LET or PRINT – they cannot be executed standalone in immediate mode.

BITMAP.WIDTH(resourceName$)

Returns the width of the named bitmap in the Resource table in pixels.

BITMAP.HEIGHT(resourceName$)

Returns the height of the named bitmap in the Resource table in pixels.

RGB(red, green, blue)

Returns a 16 bit color value for use with the DRAW statements where red, green and blue are packed into a RGB565 format for the display – 5 bits of red, 6 bits of green and 5 bits of blue – 65536 colors. The red, green and blue arguments are limited to a range of 0 → 255, with low-order bits truncated.

TEXT.WIDTH(font, var$)

Returns the width of the string var$ when rendered using the font in pixels.

TEXT.HEIGHT(font, var$)

Returns the height of the string var$ when rendered using the font in pixels.

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ACS Basic Graphics Examples

Here are a few sample programs that illustrate the various ACS Basic language graphics features and what can be done with a few lines of code.

Displaying an Animated Analog Clock

This short program displays an old-style analog clock whose hands move to show the Real-Time clock's time every second. Here is how it works.

The clock hands are drawn as elongated 3-sided polygons. Line 25 allocates the polygon vertices coordinate arrays.

The program minimizes flicker by using double-buffering; static content, the clock face image is drawn on the background surface, then copied to the work surface and dynamic content, the clock hands, are drawn on top. The work and display surfaces are then exchanged for the next update. Line 30 selects the background surface, draws the round clock face using a resource bitmap, then selects the work surface.

Line 35 establishes an event handler that will execute once a second, when the @SECOND system variable changes. Line 40 then executes continuously – except for once a second when the event handler executes.

The subroutine at lines 1000-1040 draws the clock. First the background surface is copied into the work surface. Line 1015 converts the RTC 24 hour time to 12 hour. Line 1020 computes the angle for the hour hand then calls a subroutine to draw it. Line 1025 computes the angle for the minute hand then calls the same subroutine to draw it. Line 1030 computes the angle for the second hand then calls a subroutine to draw it. Line 1035 then exchanges the work and display surfaces and line 1040 returns from the event handler.

The hand drawing subroutines initialize the polygon coordinate arrays for the appropriate hand drawn at a zero angle. The FOR/NEXT loop in lines 2010-2035 rotate the polygon coordinates to the angle for the time value. Line 2040 draws the rotated polygon (clock hand) and line 2045 returns to the event handler.

```
10 REM clock demo
15 @ANSI.ENABLE=0:@BACKLIGHT=1
25 DIM x[3],y[3]
30 @SURFACE=2:DRAW.BITMAP.TRANSP 0,RGB(0,255,0),0,0,"Clockface.bmp":@SURFACE=1
35 ONEVENT @SECOND,GOSUB 1000
40 GOTO 40
1000 REM draw clock
1005 h=@HOUR:m=@MINUTE:s=@SECOND
1010 DRAW.COPY 2,0,0,0,0,239,239
1015 IF h >= 12 THEN h=h-12
1020 a=(450-(h*30)-m/2)%360:r=60:c=RGB(0,0,0):GOSUB 1900
1025 a=(450-(m*6)-s/10)%360:r=90:c=RGB(0,0,0):GOSUB 1900
1030 a=(450-(s*6))%360:r=90:c=RGB(255,0,0):GOSUB 2000
1035 DRAW.TOGGLE
1040 RETURN
1900 REM draw minute or hour hands
1905 x[0]=0:y[0]=-4:x[1]=0:y[1]=4:x[2]=r:y[2]=0
1910 GOTO 2010
2000 REM draw second hand
2005 x[0]=-20:y[0]=-3:x[1]=-20:y[1]=3:x[2]=r:y[2]=0
2010 FOR n=0 TO 2
2015 X=x[n]:Y=y[n]
2020 x[n]=MULDIV(X,COS(a),1024)-MULDIV(Y,SIN(a),1024) + 120
2025 y[n]=MULDIV(X,SIN(a),1024)+MULDIV(Y,COS(a),1024) + 120
2035 NEXT n
2040 DRAW.POLYGON.FILLED x,y,c
2045 RETURN
```

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